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700 ROAD FOREST HABITAT RESTORATION PROJECT
SITE MANAGEMENT PLAN
CEDAR RIVER MUNICIPAL WATERSHED

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EXECUTIVE SUMMARY

The 700 Road Forest Habitat Restoration Project Area (the Project Area) is located in the center of the Cedar River Municipal Watershed, one mile south of Chester Morse Lake and seven miles southeast of the Cedar Falls headquarters complex. It is approximately one mile north of a patch of high quality old-growth forest, and is designed to provide future habitat connectivity for species dependent on late-successional forest (LSF) conditions. The Project Area consists of 481 acres, of which 395 acres will be ecologically thinned, 14 acres will be restoration thinned, and 72 acres will be retained untreated in leave units. The size of the project is designed to provide restoration of a habitat patch that is ecologically significant to species with medium home ranges (e.g., hairy woodpecker), while contributing to habitat for LSF-dependent species with large home ranges (e.g., northern spotted owl). The Project Area currently consists of a dense forest (generally >400 trees per acres) dominated by 61-67 year-old western hemlock, Douglas-fir, and western red cedar, with minor components of Pacific silver fir, noble fir, red alder, and black cottonwood. Vertical and horizontal structural complexity is minimal, understory vegetation is limited, and a low level of biodiversity is present. A cultural resources survey on the 395 acres designated for ecological thinning determined that no areas of cultural significance were present on the site.

Goals from the Cedar River Watershed Habitat Conservation Plan that apply to this Project Area are to accelerate the development of LSF characteristics, provide wildlife habitat for targeted species, and enhance natural biological diversity. Specific restoration objectives are: 1) maintain or increase the growth rate of trees, 2) increase plant species diversity/facilitate understory development, 3) increase forest structural complexity, 4) create and facilitate maintenance and recruitment of large-diameter snags and down wood (DW), and 5) protect special habitats and water quality. We will initially use ecological thinning to achieve these objectives, including canopy gap and snag creation and DW augmentation. Planting selected understory species may follow this treatment, if needed.

The Project Area is divided into twelve management units, including eight ecological thinning units, one restoration thinning unit, and three leave units, each with a different restoration treatment, collectively designed to create a mosaic of habitats at the forest patch scale. The specific treatment for each thinning unit is based on the current tree density, size, and species composition, combined with site-specific objectives. Ecological thinning will use a variable density method in which trees in all size classes will be retained, with variable (rather than uniform) spacing between remaining trees. This method will create structural complexity and habitat heterogeneity by simulating natural processes such as tree death from competition, windthrow, and other small-scale disturbances characteristic of late-successional forests. Biodiversity will be fostered not only by enhancing structural complexity, but also by retaining unusual habitat features such as trees with physical damage and all deciduous trees. Restoration thinning will thin only the most prevalent species and retain all the largest trees, while creating variable spacing between the remaining trees. Untreated leave units will not only provide heterogeneity at the local forest scale, but will also serve as comparison areas for long-term effectiveness monitoring.

The different restoration treatments will result in a range of 124-281 trees per acre being retained in the ecological thinning units. In order to achieve the overall restoration objectives and desired post-treatment tree density, 87-213 trees per acre or 30-35 percent of the existing basal area, will be removed from the ecological thinning units. This level of removal is conservative compared with other Pacific Northwest thinning projects designed for ecological restoration because this forest has not previously been thinned and strong winds in the area can cause an increased risk of windthrow. We anticipate that in order to achieve the ecological goals some of the units may require additional thinning after the trees have become more windfirm.

Only the most prevalent tree species (Douglas-fir, western hemlock, and some western red cedar) will be harvested in order to maintain existing tree species diversity and increase the relative proportion of less frequent species, resulting in higher diversity indices. There will be an upper diameter limit, above which no trees will be thinned. This will ensure that all larger trees are retained. The upper diameter limit of trees to be harvested varies by ecological thinning unit (19 inches in two units, 17 inches in three units, and limits of 15, 13, and 12 inches in the remaining three units), and is based on current scientific literature and expert silvicultural opinion. These limits are designed to achieve restoration objectives 1-4 by providing retained trees with sufficient space and reduced competition to increase their growth rate (thereby facilitating development not only of large living trees, but also future recruitment of large snags and DW); increasing light to the forest floor to foster understory shrub, herb, and tree seedling development (for species diversity and increased vertical structure); and introducing heterogeneity into the currently homogenous upper canopy to increase horizontal structural complexity. An estimated 4.4 million board feet or less will be removed from the Project Area and sold. This project is expected to be revenue neutral, with income offsetting costs associated with planning, data collection, monitoring, cultural resources surveys, log removal, and snag creation.

Twelve canopy gaps (five each of ¼ and ½ acre, and two ¾ acre) will be created, with 12 associated areas of the same sizes left untreated to create structural and habitat complexity and foster species diversity. In some gaps, selected dominant live trees will be retained, and snags and DW created. Snags will also be created throughout the Project Area (four snags per acre in seven ecological thinning units and 12 snags per acre in one unit) to provide habitat for cavity nesting species. Some larger diameter trees will be used when creating the higher density patch of 12 snags per acre. This will fulfill the dual objectives of significantly affecting the upper canopy, thereby increasing light to the forest floor, and providing larger diameter snags for those species such as pileated woodpecker that require large snags for nesting. A variety of snag creation techniques will be utilized, both to investigate the relative success of the methods and to provide a variety of habitat types over time. The tops of all created snags will be left on site as DW habitat. Down wood in addition to this amount will not be created because the volume of DW on the site is already high compared with old growth plots in other areas of the watershed.

There are three streams located in the Project Area (one permanent and two ephemeral) that will be protected during the thinning (e.g., no equipment will enter into the riparian zone, no trees will be yarded through the streams, all deciduous trees will be retained). Surveys in these streams indicated that no fish or amphibian species were present and that a significant natural barrier downstream prevents future colonization by fish. Stream habitat will be enhanced for benthic invertebrates and other stream biota through felling of large woody debris in the channel.

The only wetlands and seeps on the site are associated with these streams, and will receive the same protection as the streams. There are no other special habitats such as springs, rock outcrops, or talus slopes located in the Project Area.

This project will benefit wildlife species dependent on LSF conditions on a scale that is relevant to species with larger home ranges by providing essential habitat much sooner than if no restoration were conducted. In addition, many wildlife species should benefit immediately from the increased habitat complexity and plant species diversity, including forest bats, small mammals, birds, and amphibians.

Uncertainties exist about the amount of overstory tree growth response and the magnitude of effect on understory plants that will be derived from the different ecological thinning treatments. There is also uncertainty about the number of snags and methods of snag creation that will provide the optimal amount of habitat for cavity-nesting species, and the correct number and range of sizes of gaps and untreated skip areas to create optimal habitat heterogeneity and structural complexity. To address these uncertainties, three types of monitoring will be conducted. Compliance monitoring will ensure that contract specifications are met during implementation of restoration treatments. Effectiveness of the ecological thinning in achieving the objectives will be evaluated using a series of 12 vegetation plots within the ecological thinning and untreated leave units, a series of plots within created gaps, and monitoring a sample of created snags. Validation monitoring will determine use of the thinned areas and the created gaps by forest dwelling bats, an indicator wildlife species representative of late-successional forest conditions. All results will be compared with the untreated leave areas, to document the magnitude of response under the different treatments.

1.0 INTRODUCTION

1.1 Background

The Cedar River Municipal Watershed (CRMW) is the larger of two municipal watersheds that serve the City of Seattle. This watershed supplies 67 percent of the high quality drinking water provided to approximately 595,000 homes and businesses in Seattle and roughly 30 neighboring cities, towns, and water districts. The City owns virtually the entire 91,346-acre CRMW upstream of the Landsburg Diversion Dam, where drinking water is diverted from the Cedar River into the municipal water supply system. To protect water quality, unsupervised access is not allowed within the CRMW. The watershed is 95 percent forested and is currently managed under the 50-year multi-species Cedar River Watershed Habitat Conservation Plan (CRW-HCP), which was implemented in April, 2000 (City of Seattle 2000). "The overall goal of the HCP is to implement conservation strategies designed to protect and restore habitats of all species of concern that may be affected by the facilities and operations of the City of Seattle on the Cedar River, while allowing the City to continue to provide high quality drinking water and reasonably priced electricity to the region." (CRW-HCP: 2.4-43). The watershed is being managed as an ecological reserve using an ecosystem approach, with the goals (among others) of protecting and restoring aquatic, riparian, late-successional, and old-growth forest habitats. No harvest for commercial purposes will be conducted under the CRW-HCP, but silvicultural manipulations, including thinning and planting, will be employed to achieve a range of ecological objectives.

This document is the management plan for the 700 Road Forest Habitat Restoration Project. It includes a site description, desired future conditions, ecological objectives, key ecological processes, hypotheses, planned and potential future prescribed silvicultural restoration treatments (ecological and restoration thinning), a description of the harvest system, road plans, cost-benefit analysis, and monitoring plans. See Section 6.0 for detailed descriptions of the silvicultural treatments. A glossary is included as Appendix I. The authority for forest restoration projects is provided by the Final Cedar River Watershed Habitat Conservation Plan, signed by the City of Seattle, the United States Fish and Wildlife Service, and the National Marine Fisheries Service (City of Seattle 2000).

Selling trees removed during this project will require an ordinance from the Seattle City Council. Public input is available through a formal review process for city council ordinances, as well as an HCP oversight committee. Other public input may also be solicited. A State Environmental Policy Act (SEPA) review is not required for this project. As a fundamental component of completing and adopting the CRW-HCP, a National Environmental Policy Act (NEPA) Environmental Assessment (EA) and a SEPA Environmental Impact Statement (EIS) was successfully completed and adopted. This adoption took place on May 27, 1999, as made record by a letter from then-director Diana Gale to interested parties. As a result, any work undertaken as the direct implementation of a project or program within the CRW-HCP is already compliant with SEPA regulatory requirements. In addition, the 700 Road Forest Habitat Restoration Project would be classified as Class II under the Forest Practice Rules and therefore subject to a categorical exemption from SEPA review.

1.2 General CRW-HCP Goals and Objectives

The CRW-HCP identifies some of the watershed management goals and objectives that apply to upland forest:

> "The mitigation and conservation strategies for watershed management are designed to avoid, minimize, or mitigate for the impacts of any taking of listed species, including the spotted owl and marbled murrelet, and for the equivalent of taking of unlisted species addressed by the HCP. These strategies are also designed to provide a net benefit for the species addressed by the plan, contribute to recovery of these species, and contribute to the maintenance of natural biodiversity [see glossary] in the watershed and region. The strategies will also benefit many other fish and wildlife species inhabiting the biological communities and ecosystems of the watershed that are not specifically addressed by this HCP. Because this HCP focuses on species dependent on late-successional and old-growth forest, riparian and aquatic habitats, those species that depend primarily on the earliest seral forest habitat, such as the grass-forb-shrub stage of succession, will receive less benefit from the HCP or will lose habitat under the HCP, as these habitats will be less common than they are today." (CRW-HCP: 4.2-10)

"The general conservation objectives for watershed management are to:

- Develop strategies for watershed management, consistent with water supply functions, that protect and improve water quality, as well as aquatic and riparian habitats;
- Develop scientifically sound conservation strategies for the watershed that combine mitigation, protection, restoration, research, monitoring, and adaptive management to achieve the conservation objectives of the HCP;
- Develop strategies to restore and sustain the natural processes that create and maintain key habitats for species addressed by the HCP and that foster natural biological diversity of native species and their communities;
- Protect existing old-growth forest in the municipal watershed and promote development of additional mature and late-successional forest that will better support the native organisms characteristic of late-successional and old-growth forest communities;
- Develop an integrated, landscape approach that addresses the spatial relationship of habitats within the watershed and with regard to nearby areas to improve the ability of the watershed, over time, to support the species addressed by the HCP;
- Pursue land management approaches that, as practicable, help avoid catastrophic events such as forest fires that would jeopardize drinking water or habitats for species addressed by the HCP;
- Protect special habitats in the municipal watershed; and
- Commit not to harvest timber for commercial purposes, effectively establishing the forests in the watershed as an ecological reserve that will protect existing old-growth forest, recruit a significant amount of mature and late-successional forest, and make a significant contribution to the support of regional populations of species that depend on late-successional and old-growth forests and/or aquatic and riparian ecosystems." (CRW-HCP: 4.2-10-11)

The CRW-HCP divided the undeveloped habitat in the CRMW into three major components and developed conservation measures for each. The components are 1) late-successional and old-growth forest communities, 2) aquatic and riparian ecosystems (e.g., streams, wetlands, forested riparian corridors), and 3) special habitats (e.g., talus/felsenmeer slopes, upland meadows, cliffs, etc.). Of the 91,346 acres in the CRMW, 85,277 acres are forested, 2,914 acres are in the aquatic and riparian component, 1,809 acres are in the special habitats component, with the remainder developed. Of the forested acres, 13,980 acres are already in late-successional or old-growth conditions (>120 years old). The remaining 71,297 acres are available for recruitment into the late-successional forest habitat component (CRW-HCP: 4.2-15).

1.3 CRW-HCP Upland Forest Goals

The overriding goal of the CRW-HCP is to protect water quality for the municipal drinking water supply. In addition, numerous other goals are delineated in the CRW-HCP. Four general management goals that apply to the 71,297 acres of upland forest are to 1) accelerate the development of late-successional forest characteristics, 2) provide wildlife habitat for targeted species, 3) enhance natural biological diversity, and 4) help avoid catastrophic events. The goals of accelerating the development of late-successional forest characteristics, enhancing biological diversity, and providing habitat for late-successional forest dependent wildlife species are intertwined. Restoration treatments are designed to accelerate development of late-successional forest characteristics, including large trees, structural complexity, species diversity, habitat heterogeneity, and standing and down dead wood. The treatments will both create and maintain mosaics of habitats over a range of spatial and temporal scales, providing wildlife habitat for a variety of native wildlife species and facilitating biodiversity. While disturbances on many spatial and temporal scales are natural components of forest ecosystems in the Pacific Northwest (e.g., windthrow, forest fire, disease, and insect infestations), large-scale catastrophic disturbances may negatively impact water quality and wildlife habitat for species of concern in the CRW-HCP. As a result, if these catastrophic risks are considered to be significant, some restoration treatments may be designed to reduce that risk.

1.4 CRW-HCP Upland Forest Management Activities

The CRW-HCP identifies three primary management activities to achieve the upland forest restoration goals. “Ecological Thinning” consists of thinning forests older than 30 years, with a primary goal of accelerating the development of late-successional forest characteristics. Examples of how thinning may be used to achieve this goal include creating canopy gaps, encouraging understory development, and promoting the growth of large trees. Snags, downed logs, and tree cavities may be created where it is determined that these attributes are deficient. “Restoration Thinning” is the thinning of dense forests generally less than 30 years of age that have a relatively low level of biological diversity. The goals are to reduce competition, increase light penetration, stimulate tree growth, reduce fire hazard, and accelerate forest development to a more biologically diverse stage. Lastly, “Restoration Planting” will be conducted to develop a diversity of tree, shrub, forb, bryophyte, and lichen species characteristic of naturally regenerated forests that should support a wide range of native wildlife species.

1.5 Site Selection

The 700 Road Forest Habitat Restoration Project Area was initially selected using the professional judgement of Watershed Management Division (WMD) staff with intimate knowledge of the CRMW (over 25 years of experience in the CRMW) because the site selection process under development by the Upland Forest Restoration Interdisciplinary Team (UFRIDT) had not yet been completed. The primary criterion we used was the current condition of the forest (a high density of overstory trees with little structural complexity, minimal light penetration to the forest floor, and a general lack of understory plants). The overstory trees are in the competitive exclusion stage of forest succession, competing for limited water, nutrients, and light (see Section 4.1). This competition is substantially slowing the growth rate of the trees, thereby limiting the development of large live trees and the eventual recruitment of large snags and down wood (DW). In addition, the dense overstory canopy restricts light to the forest floor, and thus the establishment of a diversity of species of trees, understory shrubs, and herbs, which subsequently impedes structural development on the site.

Other considerations in selecting this site included:

- a growing site that will foster the eventual development of very large trees;
- proximity to the remaining old-growth forest in the Rex River sub-basin, to create habitat connectivity for animals dependent on late-successional forest conditions;
- good existing tree species diversity that provides a strong basis from which to enhance biodiversity;
- a relatively young forest (62-67 years) in which most trees still have sufficient crown depth to allow a relatively rapid response to decreased competition;
- the opportunity to implement a range of management treatments and harvest systems, allowing the comparison of methods for use in future restoration efforts; and
- the potential for more than one thinning entry into a portion of the site that will allow more finely-tuned long-term treatments.

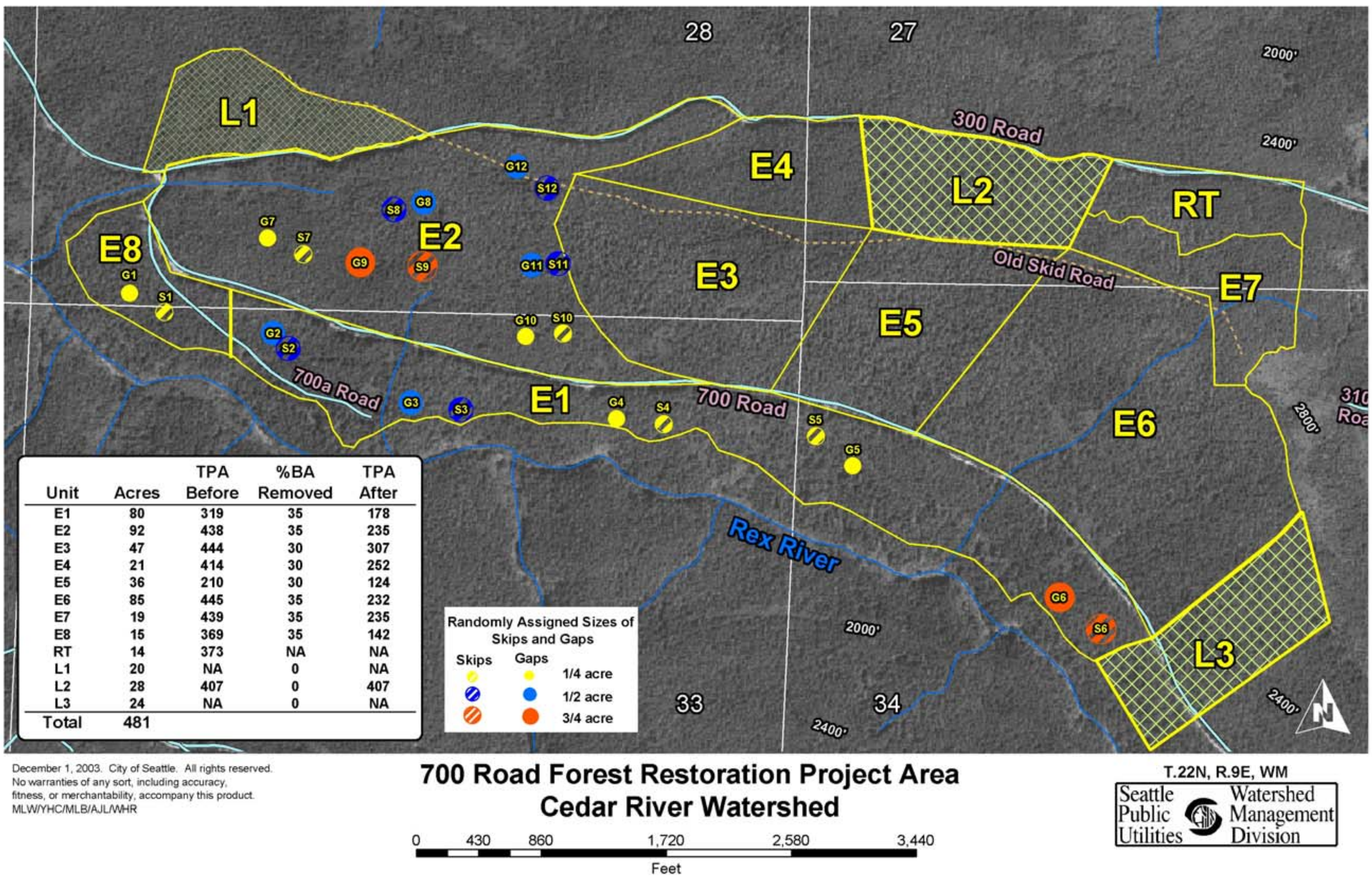
The methodology for site selection and prioritization designated in the draft of the Upland Forest Restoration Strategic Plan (Richards et al. 2004) has subsequently identified the Project Area as having forest characteristics that would benefit from ecological and restoration thinning. Also, the Project Area, when taken in concert with other proposed forest restoration activities, provides habitat connectivity between the old-growth forests patches in the Rex River sub-basin and upper CRMW with the maturing forests and 45 Road Forest Restoration Project in the lower CRMW.

2.0 SITE DESCRIPTION

2.1 Location

The Project Area encompasses 481 acres, of which 395 acres are in eight ecological thinning units (designated as E1-8), 14 acres are in a restoration thinning unit (RT), and 72 acres are in three untreated leave units (L1-3) (Figure 1). The Project Area is located in Sections 27, 28, 33, and 34 of T22N, R9E, W.M, and is bounded on the north by the 300 Road and a flagged boundary line, and on the east and south by a flagged boundary line. The junction of the 300 and 700 roads lies at the western end of the area, and the 700 road bisects the Project Area.

Figure 1. **700 Road Forest Habitat Restoration Project Area, Thinning and Leave Units**



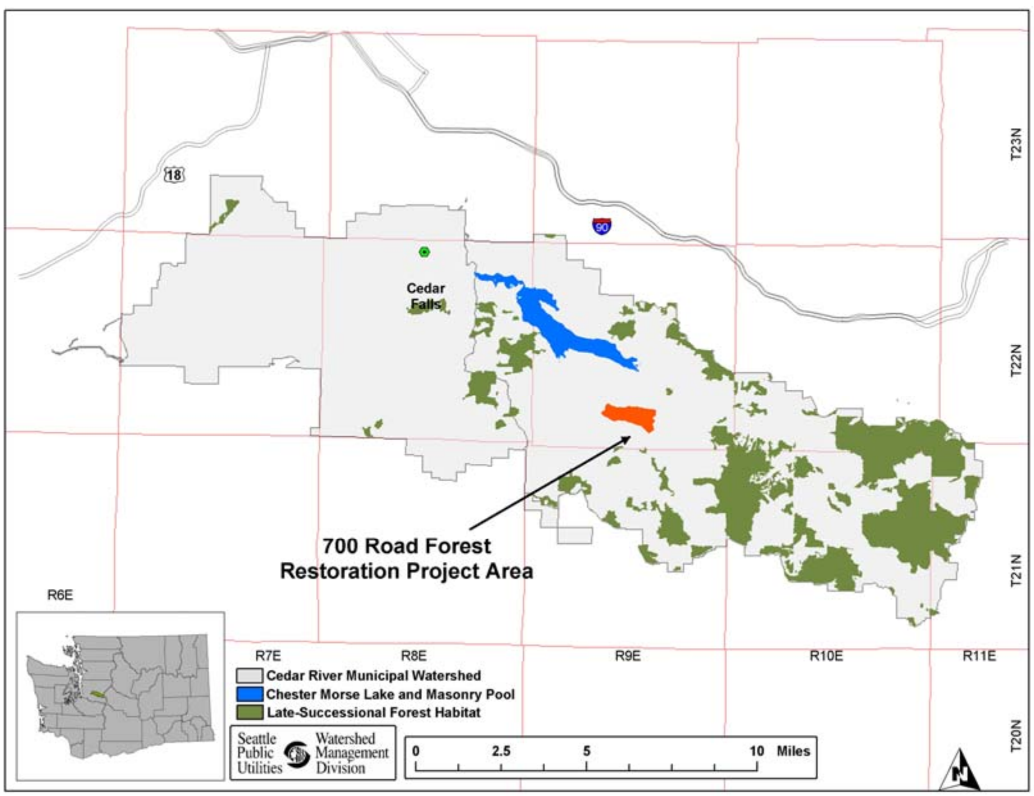
Unit	Acres	TPA Before	%BA Removed	TPA After
E1	80	319	35	178
E2	92	438	35	235
E3	47	444	30	307
E4	21	414	30	252
E5	36	210	30	124
E6	85	445	35	232
E7	19	439	35	235
E8	15	369	35	142
RT	14	373	NA	NA
L1	20	NA	0	NA
L2	28	407	0	407
L3	24	NA	0	NA
Total	481			

The site is located roughly 1.0 mile south of Chester Morse Lake, 7.0 miles southeast of the WMD headquarters at Cedar Falls, and 10.9 miles southeast of downtown North Bend, Washington.

2.2 Landscape Context

The Project Area lies within the lower Rex River sub-basin near the geographic center of the CRMW. While forest within the CRMW will not be commercially harvested during the 50-year term of the CRW-HCP, forested land outside and adjacent to the CRMW may be subject to continued rotation harvest or conversion to other landcover types. The CRMW property boundaries lie approximately 3.0 miles to the north and south of the Project Area, 10.3 miles to the east, and 14.3 miles to the west. The major landowner adjacent to the CRMW and north of the Project Area in the South Fork Snoqualmie River watershed is the USDA Forest Service (USFS). Plum Creek Timber Company owns land adjacent to the CRMW south of the area in the Green River watershed. The nearest late-successional or old-growth forest in the CRMW is approximately 1.0 mile south of the Project Area (Figure 2). The Rex River sub-basin has 1,740 acres of old-growth forest that represents 12 percent of the sub-basin. Puget Sound is approximately 31.0 miles to the west of the Project Area.

Figure 2. Late-successional forest in the vicinity of the 700 Road Forest Habitat Restoration Project Area.



Although 395 acres is a small proportion of the CRMW (<0.44 percent), it is of sufficient size to provide habitat for species with medium home range sizes, such as the hairy woodpecker

(*Picoides villosus*). It will also substantially contribute to restoration of habitat for old-growth forest dependant species on a metapopulation scale, including those species that have home ranges in the thousands of acres, such as northern spotted owl (*Strix occidentalis)*, northern goshawk (*Accipiter gentilis*), pileated woodpecker (*Dryocopus pileatus*), fisher *(Martes pennanti*), and American marten (*Martes americana)* (Morrison et al 1998, Smallwood 2001). Projects in the 300-500 acre range allow for diverse treatments at appropriate habitat patch scales, creating a mosaic that will provide habitat for a multitude of species. This would not be possible if only small isolated patches of habitat were restored. This patch size also can provide habitat connectivity on a spatial scale that is relevant to species listed in the HCP.

2.3 History and Cultural Resources

Historic Native American use in the CRMW has been well documented, although no historic villages or camps have been identified on the Project Area itself and are considered unlikely, given the location (Schalk and Schwartzmiller 2004). An historic trail has been identified along the ridge that runs east-west through the Project Area, and may have been used in prehistoric times. The area may have been used for hunting and/or gathering of resources, activities that can leave little or no permanent record, although culturally modified trees may still be present. American settlers moved into the vicinity in the late 1800s, largely to exploit the timber and mineral resources, and remnants of an old logging camp is located in the southeastern portion of the Project Area, just north of the Rex River. A two-phase cultural resources survey was implemented in 2003 (Schalk and Schwartzmiller 2004). Phase I included a pedestrian survey of the 395 acres to be ecologically thinned. Phase II involved subsurface surveys of locations of interest with high probability to contain cultural debris. No areas of cultural significance were located, and thinning is not expected to have an adverse effect on cultural resources.

The Project Area was clearcut logged from 1929-1934, which was probably followed by burning to remove logging debris (there is evidence of fire, including charred stumps and DW). The area was likely naturally reseeded, although no documentation of burning or reseeding is available for this site. The existing forest ranges from 62 to 67 years old, with the older trees at the lower elevations in E1 and E2, and the younger trees on the ridge top in E7. The Project Area has not been previously thinned.

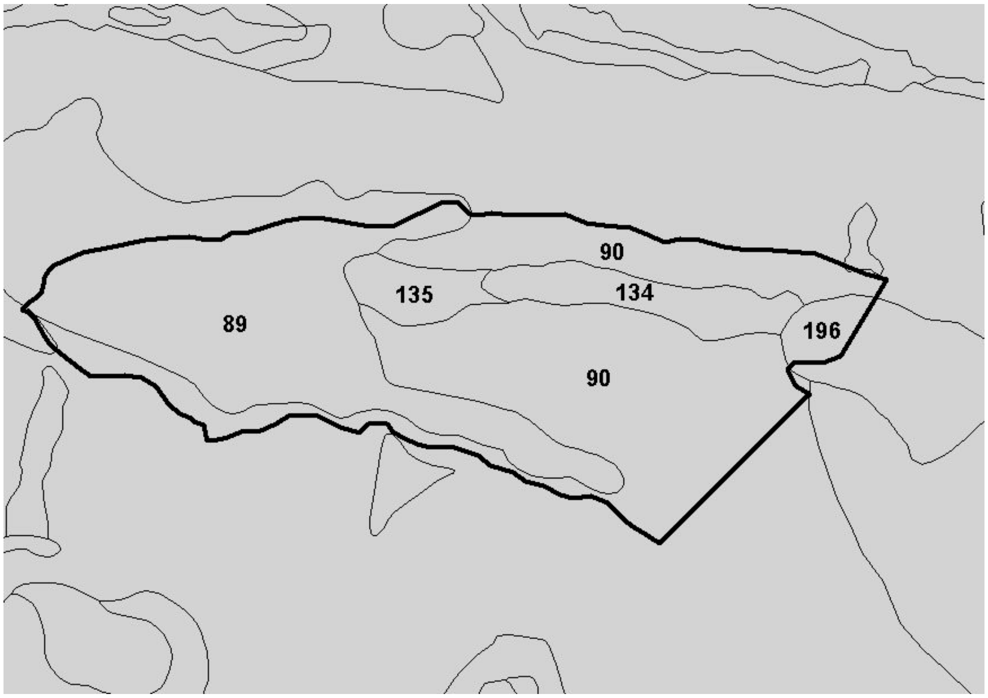
2.4 Soils

There are five types of soil on the Project Area (Table 1 and Figure 3), all formed in a mixture of volcanic ash and pumice derived from andesite (USDA-SCS 1992). Under bare soil conditions, these soil types provide a slight to moderate erosion hazard that generally increases with slope. These soils typically support overstory vegetation of Douglas-fir (*Pseudotsuga menziesii*), western hemlock (*Tsuga heterophylla*), and western red cedar (*Thuja plicata*), while Pacific silver fir (*Abies amabilis*), noble fir (*Abies procera*), red alder (*Alnus rubra*), and black cottonwood (*Populus balsamifera*) can also be present. Understory vegetation may include Oregon-grape (*Berberis aquifolium*), salal (*Gaultheria shallon*), western sword fern (*Polystichum munitum*), red huckleberry (*Vaccinium parvifolium*), and Pacific trillium (*Trillium ovatum*).

Table 1. Description of soil types found in the 700 Road Forest Habitat Restoration Project Area.

Soil Name	Slope (%)	Map ID #	Source	Elevation (ft)	Permiability	Water Capacity	Runoff	Erosion Hazard	Associated Tree Species	50-Yr Site Curve	100-Yr Site Curve	Site Class	Associated Understory Species
Kaleetan sandy loam	8-30	**89**	volcanic ash and pumice over colluvium derived from andesite and glacial till	1,600-2,800	moderate	moderate	slow	slight	Douglas-fir, western hemlock, western red cedar, red alder	DF 113	DF 145	III	Oregongrape, salal, western swordfern, red huckleberry, Pacific trillium, vine maple, deer fern, longtube twinflower, western brackenfern
Kaleetan sandy loam	30-65	**90**	volcanic ash and pumice over colluvium derived from andesite and glacial till	1,600-2,800	moderate	moderate	medium	moderate	Douglas-fir, western hemlock, western red cedar, red alder	DF 113	DF 145	III	Oregongrape, salal, western swordfern, red huckleberry, Pacific trillium, vine maple, deer fern, longtube twinflower, western brackenfern
Melakwa sandy loam	8-30	**134**	volcanic ash and pumice over colluvium derived from andesite	1,600-2,800	moderate	moderate	slow	slight	Douglas-fir, western hemlock, western red cedar, red alder	DF 104	DF 128	III	western swordfern, Oregongrape, salal, vine maple, red huckleberry, Pacific trillium, deer fern, longtube twinflower, western brackenfern
Melakwa sandy loam	30-65	**135**	volcanic ash and pumice over colluvium derived from andesite	1,600-2,800	moderate	moderate	medium	moderate	Douglas-fir, western hemlock, western red cedar, red alder	DF 104	DF 128	III	western swordfern, Oregongrape, salal, vine maple, red huckleberry, Pacific trillium, deer fern, longtube twinflower, western brackenfern
Playco loamy sand	8-30	**196**	volcanic ash and pumice mixed with colluvium derived from andesite	2,500-3,600	moderate	high	slow	slight	western hemlock, Pacific silver fir, noble fir, Douglas-fir	WH 89	WH 127	IV	montia, trillium, devilsclub, huckleberry, Oregongrape, Pacific yew, salal, western swordfern

Figure 3. Map of soil types in the 700 Road Forest Habitat Restoration Project Area. See Table 1 for description of types.



The majority of the Project Area has a tree growth potential of site class III, on a scale of I to V where the lower the site class number, the better the tree growth potential. Douglas-fir trees will typically grow to 104 to 113 feet in height over 50 years on these soil types, and 128 to 145 feet in 100 years. The soils on a small portion of the area toward the top of the ridge are site class IV, where western hemlock trees will typically grow 89 and 127 feet tall, in 50 and 100 years respectively.

2.5 Elevation and Topography

The elevation of the Project Area ranges from 1,760 to 2,840 feet above sea level (asl), with slope varying from 0 to 50 percent (Figure 1). A ridge runs downhill from east to west through the middle of the area, creating south, west, and north facing aspects. Gently sloped areas are primarily on the west and south sides of the Project Area, as well as along the apex of the ridge. Relatively steeply sloped areas occur on the north and south sides of the ridge.

2.6 Climate

The climate of the Project Area is typical of weather on the west slope of the Cascade Mountain Range in Washington, where conditions are highly variable and dependent upon elevation, topography, aspect, and latitude. The nearest weather station is located at Chester Morse Lake (previously known as Cedar Lake) near the Masonry Dam, which is 1,560 feet asl (data available at: http://www.wrcc.dri.edu). Temperatures at the station range from an average monthly maximum of 72°F in August, to an average monthly minimum of 30°F in January. Annual average precipitation is 102 inches, falling primarily as rain from October to March. Annual snowfall averages 68 inches. The Project Area receives strong southeasterly fall winds, and occasional strong northeasterly spring winds.

2.7 Aquatic Resources

The southern sections of the Project Area drain directly into the Rex River, while most of the northern sections drain into the Rex River via Morse Creek. Units E4, L2, RT, E7 and portions of E2 drain into the upper Cedar River via Eagle Ridge Creek. Both the Rex and Cedar rivers flow into Chester Morse Lake, which when taken with the Masonry Pool, provides a 1,690-acre reservoir that is controlled by the Masonry Dam. From the Masonry Dam, the Cedar River flows approximately 14 river miles downstream to the water supply intake at the Landsburg Diversion Dam, and ultimately into Lake Washington approximately 22 river miles downstream of Landsburg.

2.7.1 Streams

Three unnamed surface streams (one permanent and two ephemeral) have been identified within the Project Area (Figure 1). The permanent stream is located at the west end of the Project Area in E2. It flows in a westerly direction from its point of origin, located about 1,200 feet east of the 700-300 road junction. Immediately above the 700 road the channel is moderately entrenched into alpine till. Boulders (from the till) as well as scant in-channel large woody debris (LWD) currently form steps within this 4-6% gradient step-pool channel. Approximately 500 feet upstream, the channel becomes an unentrenched 2-4% gradient channel dominated by root and LWD-formed steps. Within this upper reach, roots and small LWD seem sufficient to maintain natural channel processes. Overall stream power through this reach is low, reflecting the small drainage area and gentle gradient. No secondary or overflow channels were observed along this stream.

At the point of origin, the stream flows through conifer-dominated forest. At about 500 feet from the origin the riparian area becomes dominated by deciduous trees that persist until the 700-300 road junction, at which point the stream passes through a culvert and out of the Project Area. It then continues its westerly flow to the Rex River. The stream is not passable by bull trout (*Salvelinus confluentus*) or rainbow trout (*Oncorhynchus mykiss*) from the Rex River because of a seven-foot drop at the Rex River and a 30 percent bedrock cascade for almost 400 feet below the 700 road. No fish or amphibians were found in this stream during surveys conducted by WMD staff in the spring of 2003.

The eastern ephemeral stream has a southerly course through the E2 and E1. This un-entrenched, 1-4% gradient step-pool channel has a very small drainage area and low stream power. Large woody debris and roots function to form steps and stabilize banks. Small, adjacent wetlands dominated by cedar and deciduous trees are present near the head of the channel. Within this upper reach, roots and small LWD seem sufficient to maintain natural channel processes in this tributary. Below the 700 road, the channel becomes very weakly defined and eventually goes subsurface.

The western ephemeral stream flows in a southwesterly direction through E7 and E6 and the eastern portion of E1. It is a steep (generally >20% gradient) cascade channel that is mostly ephemeral with no chronic bank erosion or obvious slope stability issues. In-channel LWD levels are low throughout the extent of the channel and existing wood is generally highly decayed. Primary wood functions include step formation and sediment storage. Within Unit E7 the channel becomes unconfined, is significantly more gentle (<10% gradient), less distinct, and is flanked by numerous seeps. Below the 700 road (in E1) the channel splits, with an approximate 125-foot wide island of conifer trees between them.

No amphibians were detected in either of these ephemeral streams during surveys in the spring of 2003.

2.7.2 Wetlands

There are no wetlands or seeps in the Project Area that are not closely associated with the streams described above.

2.7.3 Special aquatic areas

No special aquatic areas, such as springs, occur in the Project Area.

2.8 Vegetative Resources

The Project Area lies in the transition between the Western Hemlock and Pacific Silver Fir Zones in the western foothills of the Cascade Mountains (Franklin and Dyrness 1988). Prior to American settlement in the region, these zones were subject to natural disturbances such as windthrow, disease and insect infestation, and catastrophic forest fires. Typical fire-return intervals in this area of the western Cascades range from one hundred to several hundred years (Agee 1993).

2.8.1 Overstory

The current forest overstory vegetation is dominated by 61-67 year-old Douglas-fir and western hemlock trees that originated in the late 1930s following clearcut logging in the late 1920s and early 1930s. There are also significant numbers of western red cedar and Pacific silver fir trees, with some red alder, noble fir, black cottonwood, and Pacific yew (*Taxus brevifolia*). The trees on the lower slopes have generally exhibited greater growth (E1, E2, and E8), but all of the ecological thinning units have some larger trees. Shade intolerant Douglas-fir trees typically provide a dominant overstory with shade tolerant western hemlock comprising co-dominant and subdominant canopy classes.

A forest inventory was conducted on 437 acres of the Project Area (L1 and L3 were omitted) in September 2001. A variable radius plot method was used to quantify certain tree characteristics roughly every two acres, which resulted in 216 plots. Based on this inventory information and field reconnaissance, eight units with relatively unique characteristics were identified for ecological thinning (E1-8), one unit for restoration thinning (RT), and one unit to be left untreated (L2). A summary of this information is included in Appendix II. Areas L1 and L3 were chosen because of their similarity to E1, E2, and E6, and will have comparable data collected during 2004 to document baseline conditions.

In the units designated for ecological thinning, the density of live trees ≥6 inches in diameter at breast height (dbh) ranges from 210 to 445 trees per acre (E5 and E6, respectively). Average tree diameters range from 9.3 to 14.4 inches quadratic mean dbh (E7 and E1, respectively), with a maximum tree diameter of 33 inch dbh in E1 and E2. Maximum tree height ranges from 104 to 139 feet (E4 and E1, respectively). Tree species abundance is dominated by western hemlock in all of the units (ranging from 50 to 75 percent of the trees per acre in E3 and E6, respectively). Douglas-fir is the second most abundant species in all units except E1 and E4. Western red cedar provides significant species abundance (greater than 5 percent) in all units except E5. Pacific silver fir is present in five of the seven ecological thinning units, but is only significantly abundant in E3 (8 percent). Deciduous trees (red alder and black cottonwood) were detected in Units E1, E2, and E6. See Section 6 and Appendix II for a complete description of current overstory tree data by thinning unit, as well as the projected leave tree data after thinning.

The forest inventory of the restoration thinning unit (RT) provides limited data because it ignores trees less then 6 inches dbh, which make up a significant portion of the trees. There are 373 trees per acre that are ≥6 inches dbh, with the largest tree being 14 inches dbh. Western hemlock and Douglas-fir (both over 40 percent) are most abundant, but there is also a significant number of western red cedar (12 percent). No deciduous trees were identified.

The forest inventory data for L2 indicates that there are 407 trees per acre ≥6 inches dbh, with an average diameter of 9.1 inches quadratic dbh. The largest diameter tree in L2 is 22 inches dbh, and the species abundance is dominated by western hemlock (55 percent). Western red cedar, Douglas-fir, and Pacific silver fir are also significantly abundant in this untreated leave unit.

2.8.2 Understory

No understory data were collected with the 2001 forest inventory. Some understory data were collected in 1992, however, as a supplement to a forest inventory conducted in a portion of the Project Area (E5, E6, E7, L2, RT, L3, and a small portion of the eastern end of E1) (Mason, Bruce, and Girard 1992). Seventeen herb and shrub species were identified, with Oregon grape, sword fern, salal, red huckleberry, and vine maple predominating (Table 2). Forty of the 43 plots contained some understory vegetation, although only 14 plots had ≥50% cover, with most plots having less than 25% cover. This is consistent with general field observations made in 2003 of a generally depauperate understory vegetation with little tree regeneration.

2.8.3 Biological Legacies, Snags, Stumps, and Down Wood

The 2001 forest inventory of the Project Area identified snags (all western hemlock) in only three of the ecological thinning units (E1, E2, and E3) (see Appendix II). The largest snag measured (20 inches dbh) was sampled in E1, with no other snags larger than 14 inches dbh sampled. In the 1992 survey, a portion of the Project Area (E5, E6, E7, L2, RT, L3, and a small portion of the eastern end of E1) was sampled for snags as a supplement to a forest inventory (Mason, Bruce, and Girard 1992). This survey also found large snags to be scarce (Table 3). On 43 plots, 28 snags were sampled, with the largest 18 inches dbh. The average diameter was 8.1 inches dbh, with 17 of the sampled snags ≤8 inches dbh. All were decay class I (i.e., little decay, indicating recent mortality). Species composition consisted of two Douglas-fir, four red alder, eight Pacific silver fir, eight western hemlock, and six unknown. Prior to the 1980s, snags were routinely removed from logging areas as a safety precaution.

Table 2. Understory species occurrence, with number and percent of plots by cover class[a] in the 700 Road Forest Habitat Restoration Project Area[b], 1992 study.

Species	Species Occurrence		≥50% cover		25-49% cover		<25% cover	
	# Plots	% Plots	# Plots	% Plots	# Plots	% Plots	# Plots	% Plots
Alaska blueberry	6	14	0	0	0	0	6	14
Bunchberry dogwood	2	5	0	0	0	0	2	5
Beargrass	1	2	0	0	0	0	1	2
Pacific blackberry	3	7	0	0	1	2	2	5
Foamflower	5	12	0	0	0	0	5	12
Devil's club	3	7	0	0	0	0	3	7
Deer fern	8	19	0	0	0	0	8	19
False lily-of-the-valley	1	2	0	0	0	0	1	2
Lady fern	6	14	0	0	1	2	5	12
Oregongrape	30	70	5	12	5	12	20	47
Queen's cup	1	2	0	0	0	0	1	2
Red huckleberry	15	35	0	0	1	2	14	33
Rosy twistedstalk	3	7	0	0	0	0	3	7
Salal	25	58	5	12	4	9	16	37
Sword fern	21	49	2	5	1	2	18	42
Vanilla leaf	1	2	0	0	0	0	1	2
Vine maple	14	33	2	5	2	5	10	23

[a]Because cover by understory species can overlap, and not all species occurred on all plots, percentages do not add to 100.
[b]43 plots = 2.15ac total sampled

Table 3. Snag and stump data from plots sampled in the 700 Forest Habitat Restoration Project Area[a], 1992 study.

Habitat Element	Diameter Class	# Sampled	Average diameter	Range of diameters	Estimated #/acre
Snags	≥16" dbh	1			0.5
	9-15" dbh	10			4.7
	≤8"dbh	17			7.9
Total		28	8.1	4-18	13.1
Stumps	>30"dbh	29			13.5
	20-29"dbh	48			22.3
	10-19"dbh	42			19.5
	<9"dbh	2			0.9
Total		121	24.8	9-80	56.2

[a]43 plots = 2.15ac total sampled

Residual stumps of the forest that stood on the site prior to being clearcut harvested in the early 1930s were also sampled in the 1992 survey (Table 3) (Mason, Bruce, and Girard 1992). Of the 121 stumps sampled on the 43 plots, 24 percent were >30 inches dbh. Estimated dominant tree density (those greater than 20 inches dbh) was 36 trees per acre. These data are consistent with data collected on residual stumps from two one-third acre plots in E5 and E6 in 2002. The first plot contained 19 stumps, with an average diameter of 36.7 inches (range 20 to 54). The second plot had 12 residual stumps with an average diameter of 41 inches (range 24 to 60). The samples indicate a dominant tree density in the original forest of 36 to 57 trees per acre with a basal area of 350 to 460 ft^2 per acre. It was not possible to determine the species of the stumps because of the amount of decay. Application of these data towards current treatments is problematic due to the varying decay rates of different tree species and sizes. The data do indicate the site potential, may portend future conditions, and begin to establish a reference condition approximation.

Down wood was sampled from 37 66-foot transects in 1992 from the same areas described for understory vegetation, snags and stumps (Mason, Bruce, and Girard 1992). They measured 113 pieces of DW, ranging from five to 50 inches and averaging 15.8 inches diameter where the transect crossed the piece. Estimated volume of DW from this sample was 5,352 ft^3/ac. Although DW was not sampled in 2001, field observations indicated the amount varied throughout the Project Area, attributable to the differing levels of competitive mortality. A large amount of large diameter DW is present in L2, possibly a result of cutting of snags generated from an escaped burn set to control logging slash. This untreated leave unit was designed in part to protect this important habitat element.

2.9 Wildlife Habitat

The second-growth forest in the Project Area potentially provides habitat for a suite of wildlife species, including bats, small and large mammals, amphibians, and birds (Appendix III). Wildlife respond not to forest age, but rather to ecological characteristics such as structural complexity, plant community composition, species diversity, and dead wood elements (snags and DW), that together provide food, shelter, and moisture requirements. As described above, most of the thinning units currently consist of relatively small-diameter western hemlock and Douglas-fir trees with limited understory, providing adequate wildlife habitat for few species and individuals (Aubry et al. 1997).

This forest lacks characteristics typical of late-successional forest, such as large trees, snags, DW, a variety of berry-producing shrubs, mast-producing trees or shrubs, canopy layering, tree species diversity, and variable tree densities. Because 28 of the 83 species listed in the CRW-HCP are associated with late-successional forest habitat (the others requiring riparian or other "special" habitats), actions facilitating the development of these characteristics are a primary management goal. Native species not listed in the CRW-HCP are also considered during management planning as long as there are no conflicts with the overall goals of the CRW-HCP. A list of wildlife species that potentially could use the Project Area, either now or in the future, along with key habitat elements the area might provide, is included in Appendix III.

Accelerating this area toward late-successional forest conditions should provide valuable wildlife habitat for species dependent on LSF conditions and foster increased biological diversity, which is especially important in the local and regional landscape context. In addition, because ecological thinning will facilitate short-term responses by understory plants, it should provide immediate habitat benefits for numerous species, including several species of forest bats, small mammals, amphibians, and birds (Aubry et al. 1997, Hagar et al. 1996, Haveri and Carey 2000, Humes et al. 1999, Muir et al. 2002, Suzuki and Hayes 2003, Wilson and Carey 2000).

2.10 Special Habitats
No special habitats (e.g., talus slopes, rock outcrops, meadows) occur in the Project Area.

3.0 DESIRED FUTURE CONDITIONS

The desired long-term future condition of the Project Area includes characteristics consistent with late-successional conifer forests of the region that are subject to similar environmental constraints. These characteristics include large trees (stumps indicate that trees >60 inches dbh have grown on the site); a greater diversity of tree, shrub, forb, and bryophyte species; a greater variety of tree sizes and densities incorporating both horizontal and vertical structural complexity; more small canopy gaps; and a greater abundance of large snags and DW occurring in patches across the Project Area.

Late-successional forest conditions in the Pacific Northwest vary with different environmental conditions (elevation, soil productivity), the site's ecological history (type and frequency of disturbance), and long-term climate. In addition, a key characteristic of old-growth forest is its inherent variability and spatial heterogeneity (characteristics we are simulating with restoration treatments). This variance in conditions makes establishing specific numeric targets for desired future forest characteristics and restoration objectives difficult, if not impossible. We have developed hypotheses about the response of the forest to the restoration treatments, however (see section 4.3 for specific hypotheses as related to ecological objectives and processes). Generally, in the short and intermediate terms we anticipate the restoration treatments will increase the growth of co-dominant trees, result in crown elongation through epicormic branching, increase seedling initiation, and increase the cover of shrubs and forbs as compared with the untreated leave areas. Structural complexity (both vertical and horizontal) should be increased in the treatment areas relative to the leave areas as a result of the understory plant response and those thinning treatments that will retain a portion of the existing understory trees (units E1-7). These conditions should support a variety of native wildlife species over the short, intermediate, and long-term that will not occur in the untreated leave areas or much of the surrounding area because of their lack of habitat diversity and available niches. Species utilizing the site should eventually include many of the 28 LSF dependent species listed in the CRW-HCP (Appendix III). Monitoring the success of forest restoration on this site will concentrate on documenting measurable key forest attributes that are targeted by our restoration treatments, and comparing them to similar leave areas where no restoration activity is implemented (see section 9).

4.0 FOREST PROCESSES AND ECOLOGICAL THINNING

4.1 Overview of Forest Development
Numerous models have been developed that classify Pacific Northwest forest development into stages. These range from the simple four-stage model of Oliver and Larson (1996) that focuses on live trees in dense, even-aged stands to the recent eight-stage model of Franklin et al. (2002). Oliver and Larson's (1996) stages include: 1) stand initiation or early-successional, 2) stem exclusion or mid-successional, 3) understory reinitiation or late-successional forest, and 4) old-growth or shifting mosaic. The stand initiation stage occurs as tree seedlings become established throughout the forest stand, either naturally or by planting, following a stand replacement event

(e.g., clearcut harvest, forest fire). This stage can last for several decades. The stem exclusion stage occurs when the trees have grown to a size such that they are competing with one another for resources (e.g., sunlight, nutrients, and water). This stage generally occurs when the stand is 20 to 100 years old and results in decreased growth rate and significant tree mortality. The understory reinitiation stage occurs after tree densities have decreased, either through competition mortality or thinning, and the tree canopy opens to allow greater sunlight penetration to the forest floor. Understory plants and a new cohort of trees are then able to establish under the overstory trees. This stage generally occurs from 60 to 200 years old. The old-growth stage occurs when the dominant trees become very large and the understory is developed enough to have several layers (e.g., subdominant trees, saplings, seedlings, shrubs, and herbs). Shifting mosaic refers to the dynamics of the old-growth stage where dominant trees periodically fall to create canopy gaps (Franklin and Waring 1980). Tree growth and competition occurs within these gaps until dominance is reestablished, but usually by shade tolerant species as opposed to the shade intolerant pioneers. The old-growth stage generally occurs when a stand is greater than 180 years old.

The stages in the Franklin et al. (2002) model are more structurally based and cover a much broader range of time (up to 1,200 years). Their disturbance and legacy creation stage occurs prior to stand initiation. The next two stages, cohort establishment and canopy closure, correspond roughly to Oliver and Larson's (1996) stand initiation and early stem exclusion stages. The fourth stage, biomass accumulation/competitive exclusion, corresponds to the stem exclusion phase and beginning of understory reinitiation. The maturation stage covers the remainder of the understory re-initiation and early old-growth stages. Then older forest is split into three further stages: vertical diversification, horizontal diversification, and pioneer cohort loss.

4.2 Ecological Thinning

The best emerging science indicates that thinning younger forests can accelerate development of LSF conditions (Tappeiner et al. 1997, Carey et al. 1999, Carey et al. 1999b, Garman et al. 2003). There is also evidence that older forests (>100 years) can respond favorably to thinning (Williamson 1982). Ecological thinning in the CRMW seeks to reduce inter-tree competition, increase residual tree growth, and increase the structural heterogeneity and biological diversity of the forest using the most current techniques and best available science. The goals are to shorten the competitive exclusion phase, prevent stagnation in forest development, and accelerate the forest from the competitive exclusion stage that provides little wildlife habitat to the more biologically diverse understory reinitiation or maturation phase that will provide habitat for a broader range of wildlife species. Thinning should allow remaining trees to maintain or increase their rate of growth, while simultaneously providing more sunlight for understory growth and seedling regeneration. Ecological thinning seeks to mimic the structural heterogeneity found in late-successional forests by leaving a variety of tree sizes (diameter and height), spacing, and densities throughout the forest, including leaving some areas unthinned.

Removing only understory trees that are not in the co-dominant canopy position (i.e., thinning from below), the technique often used in standard commercial thinning, is unlikely to significantly affect the light regime on the forest floor. In addition it would eliminate some structural elements such as slower-growing shade tolerant plants that contribute to plant and wildlife habitat diversity (Lindenmayer and Franklin 2002). Consequently, the goals of increasing forest vertical structural complexity and increasing the understory species diversity would not be achieved. While thinning from below is considered better than no thinning for forest restoration, studies suggest that customized harvests designed to achieve variable densities within stands and augmenting snags, understory species, and down wood are ecologically preferable (Anonymous 2003, Carey et al. 1999, Lindenmayer and Franklin 2002, Muir et al. 2002).

Because maximizing tree growth is not the goal as it would be in commercial thinning, we will balance the objectives for increasing tree growth with the other objectives to facilitate development of habitat complexity and diversity. Consequently, a variable density thinning method will be used, which, in contrast to standard thinning from below prescriptions, leaves trees across smaller size classes as well as larger diameter trees and creates variable (rather than uniform) spacing between trees (Carey et al. 1999). This treatment is designed to simulate natural processes such as tree death from competition, windthrow, lightning, disease, or insects, and other small-scale disturbances that combine to create the structural complexity and biological diversity observed in late-successional forests. Trees with unusual features or physical damage (e.g., forked tops, broken tops, mistletoe brooms) are important components of biodiversity, and will be retained during the thinning treatment. Additionally, the few existing large snags and DW will be retained and new snags and logs will be created, thereby furthering the structural complexity of the Project Area.

Lindenmayer and Franklin (2002) recommend using multiple techniques to create structural complexity and compositional diversity in previously harvested forests, including:

- thinning to grow large diameter trees;
- variable density thinning (creating canopy gaps, leaving untreated skip areas, as well as varying spacing between trees);
- thinning from “above” by selectively removing some dominant trees or branch pruning to sustain or release shade-tolerant understory trees and understory shrubs and herbs;
- conservation of tree or other plant species that fulfill different structural and functional roles (i.e., deciduous trees, and species with edible fruits, distinctive bark or branching, or high capacity to host epiphytes);
- conserving and creating decadence (snags, logs, cavities); and
- planting desired tree or understory species.

The 700 Road Forest Habitat Restoration Project will utilize all these recommendations to retain and increase elements of biodiversity, including the selective removal of some dominant or co-dominant tree canopy by means of snag creation. The trees remaining after thinning will be able to maintain, and in many cases, accelerate growth. This continued growth will lead to larger live trees that will provide greater structural complexity (e.g., bark, branches, crown, roots), increased wildlife habitat value, and more biological diversity in the future. Ultimately, some of these large trees will be naturally recruited as large snags and DW. Opening the canopy through ecological thinning and gap creation will encourage understory development and tree regeneration. Retaining various sized areas in denser patches (not thinned) will help create within-site variability, simulating a natural forest pattern. In addition, the snag creation will supplement this critical habitat element for numerous wildlife species while the forest matures to a stage when it begins naturally producing larger snags. Because forest restoration is a new science, the efficacy of these silvicultural treatments will not be completely known for many years or decades. We are using the most current literature and expert opinion in designing treatments to maximize the probability of the achieving an ecological outcome that will most benefit species dependent on LSF in the long term, while at the same time benefiting numerous other species in the near term.

4.3 Hypotheses About the Effects of Ecological Thinning on Key Forest Processes

Several key forest processes, including soil formation, primary productivity, food webs, and nutrient cycling will be influenced by the restoration treatments. Forest successional development, however, is the primary process that we expect to influence with ecological thinning. The numerous processes associated with successional development can be divided into four categories: individual tree, canopy, dead wood, and understory processes (Figure 4). All of these processes are complex and interrelated, and lead to forest structural development.

We developed specific hypotheses about the effect of ecological thinning (including thinning, and creation of canopy gaps, snags, and DW) on each of these processes (Figure 5). The primary influence that we expect to have on individual tree growth processes is either a maintenance or increase in all aspects of tree growth (diameter, crown dimensions, and height to a lesser degree) and an increase in shade tolerant tree regeneration. Because most trees on the Project Area currently average 40% live crown, we predict that it will take at least five years to measure an overstory growth response resulting from the decreased competition and increased light availability. We predict that the growth response will continue for at least 20 years until the canopy again begins to close. Understory tree regeneration will most likely be measurable within five years.

We expect a significant increase in canopy elaboration over time, including development of multi-layered or continuous canopy through growth of shade-tolerant species and establishment of epicormic branching on intolerant dominants as a result of the thinning and gap creation. The created gaps will provide this forest successional element in the short term as the forest is maturing to a point where gaps will begin to be created naturally. We expect the canopy gaps to decrease in size within 15-20 years due to branch elongation, and to close within several decades due to tree regeneration. We believe the dominant trees retained in the larger gaps (see Section 6) will greatly benefit from the increased light, and develop into large trees with sufficient branch structure to provide an important habitat component in the long-term (e.g., nesting platforms for northern goshawk). These residual trees will also serve as shelterwood protection for initiation of various vegetation communities.

We expect that the greatest short-term effect of thinning and gap creation will be on understory development, an ecological element that is generally lacking throughout the Project Area. The understory plants are expected to persist in the gaps and also in the forest matrix because we expect that the canopy will not completely close with the existing cohort. This should provide long-term habitat for numerous small mammals and bird species.

Figure 4. Summary of Processes Included in Forest Successional Development Predicted to be Influenced by Silvicultural Interventions.

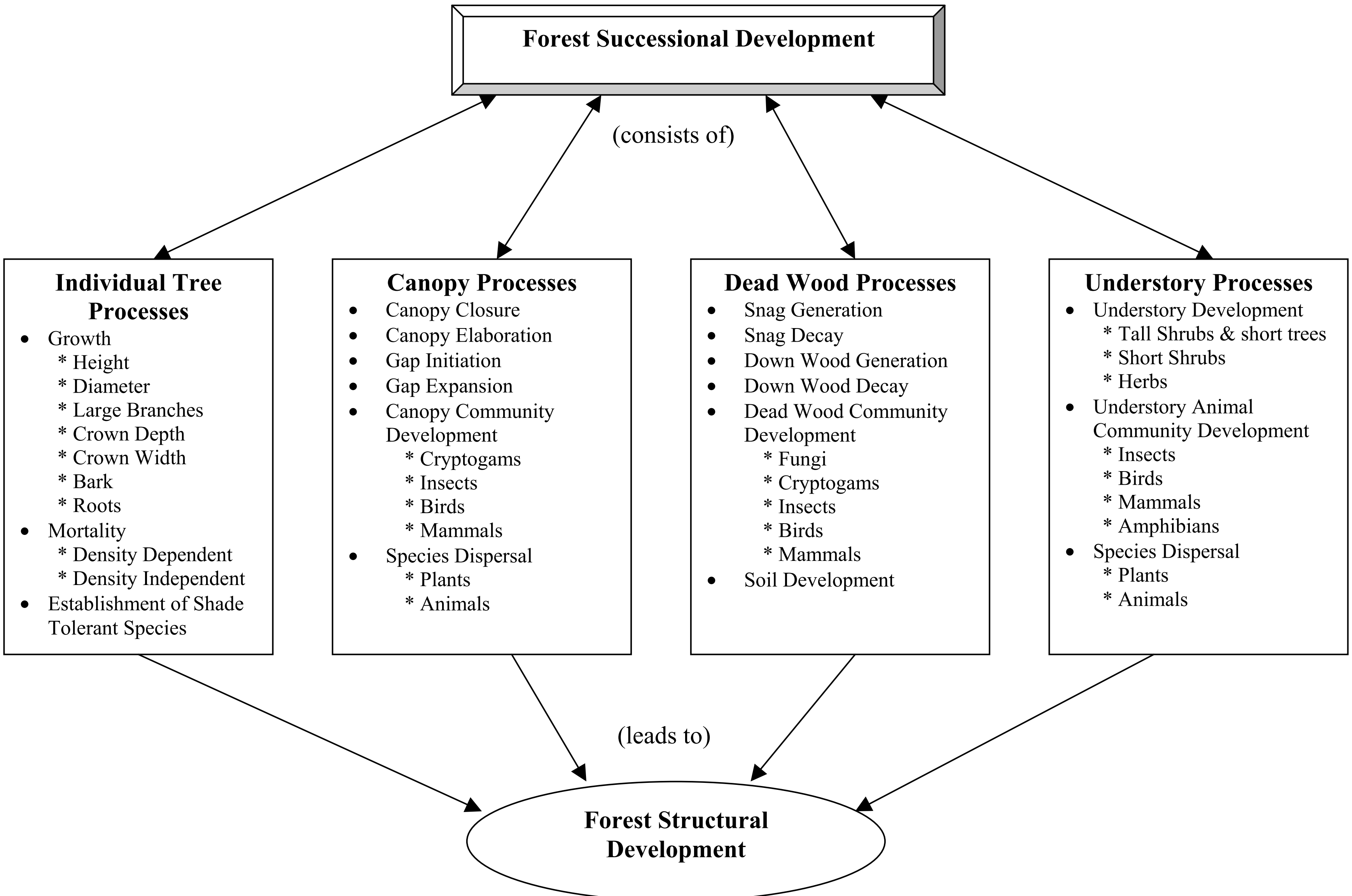


Figure 5. Basic conceptual diagram of the predicted effects on ecological processes by silvicultural interventions, 700 Road Forest Habitat Restoration Project Area.

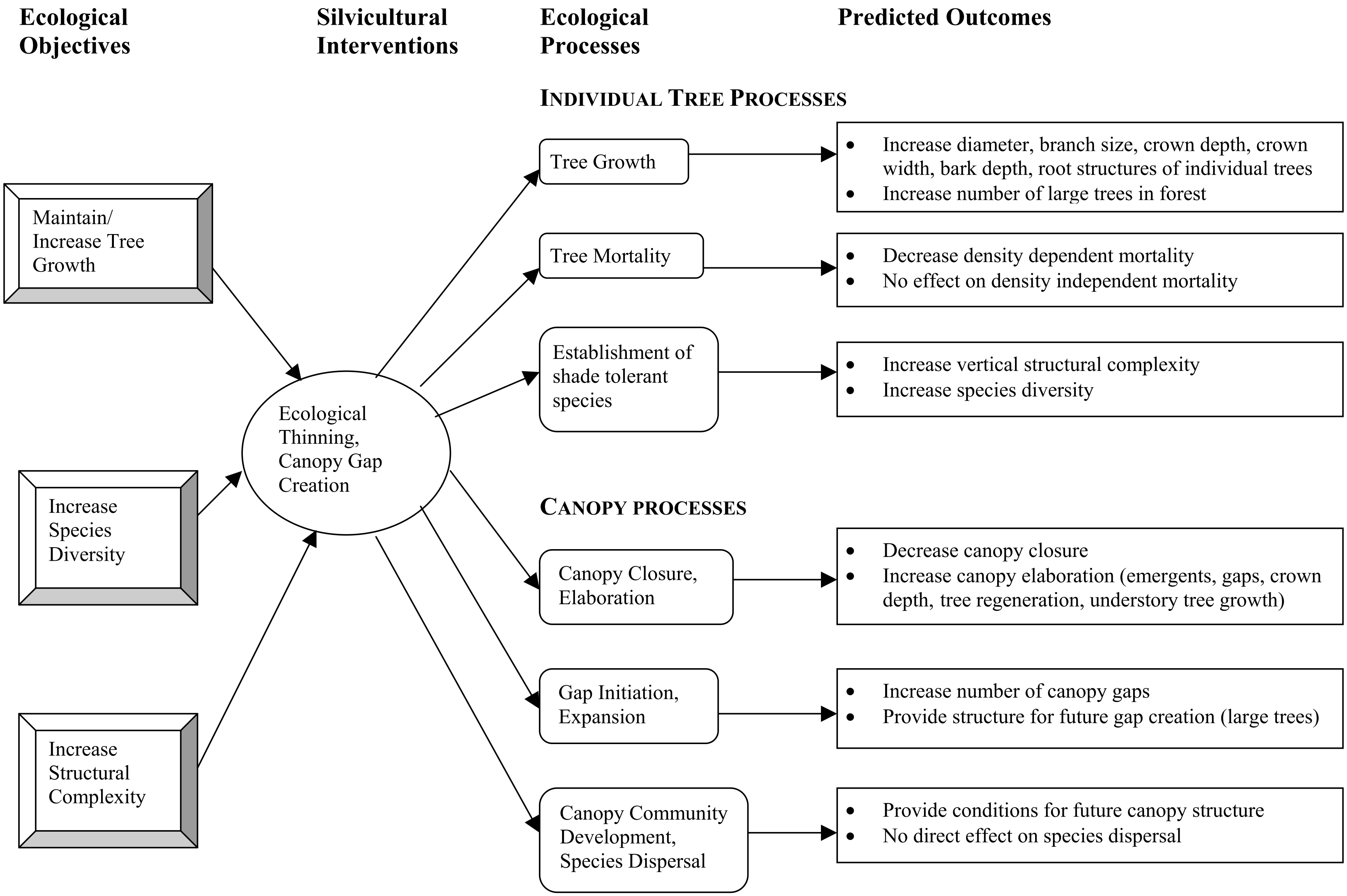
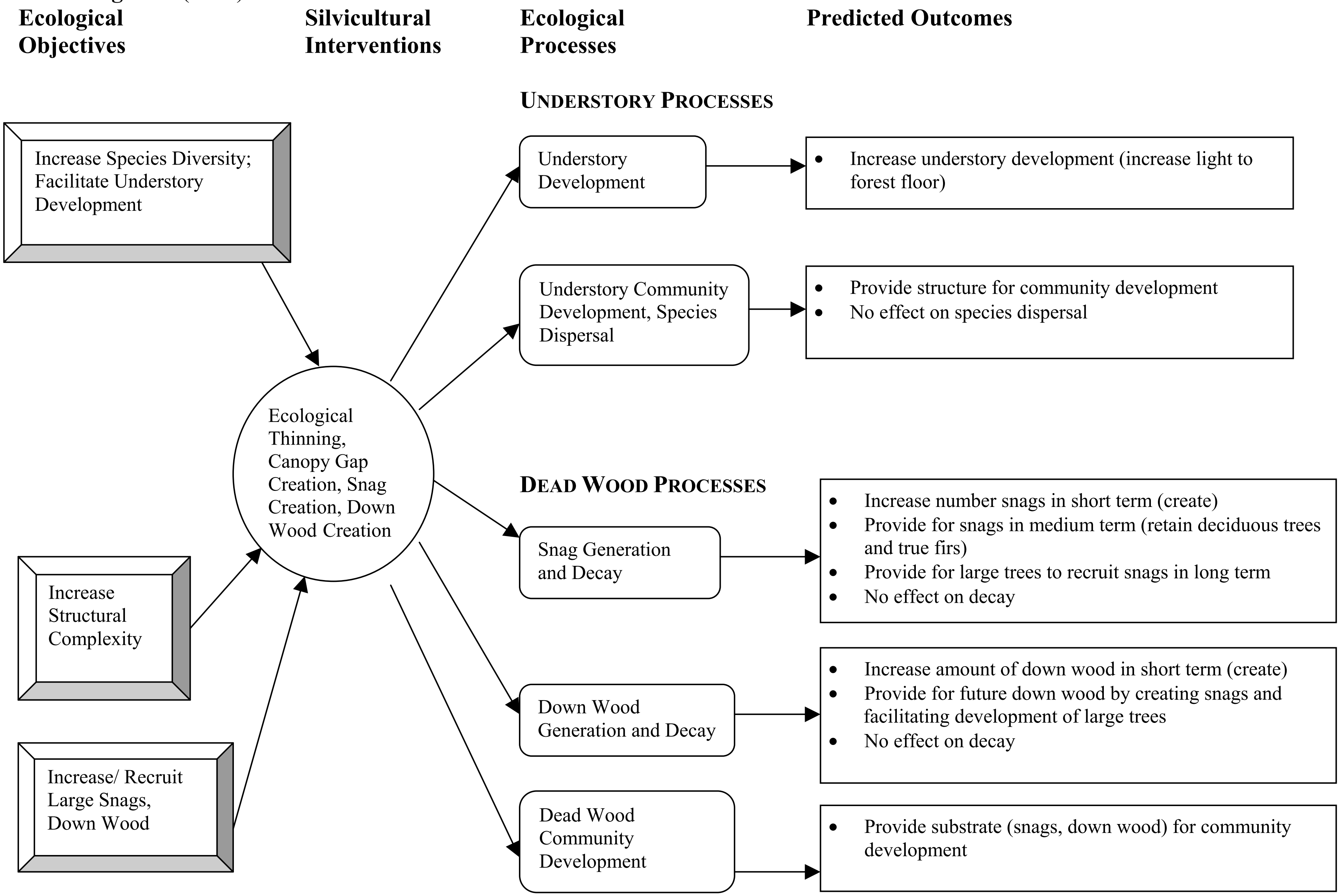


Figure 5 (cont.)



If the canopy does close completely in the future and competition appears to be slowing the growth rate and decreasing the understory component, we may reenter some units in the Project Area for additional thinning. We will review ecological conditions in the Project Area in approximately 15 years to assess the necessity for future intervention (see section 6.3 for complete discussion of possible future treatments).

Dead wood processes will be enhanced in the short term by snag creation throughout the Project Area (both throughout the forest matrix and in the larger canopy gaps), and DW creation in the gaps (entire trees) and in the matrix (tree tops from the created snags). We predict that dead wood will be provided in the medium term by retaining understory deciduous and true fir species. These species have a shorter life span and will be unlikely to successfully compete with larger dominant and co-dominant trees. Dead wood will also be provided by the continued competition mortality in the untreated leave and small skip areas. In the long-term, natural mortality processes such as windthrow, disease, and insect damage will continue to provide dead wood. Soil formation processes will be enhanced by the variety of sizes of dead wood provided to the forest floor (e.g., the wide range of sizes of existing DW, the small diameter branches from the thinned trees, the intermediate sizes of DW from snag creation).

5.0 OBJECTIVES AND PRESCRIBED SILVICULTURAL TREATMENTS

5.1 Broad CRW-HCP Goals

Three of the forest management goals specified in the CRW-HCP apply to this Project Area: 1) accelerating the development of late-successional forest characteristics, 2) providing wildlife habitat and 3) fostering natural biological diversity. Because much of the Project Area currently is covered with small diameter, densely stocked trees, has relatively low vertical and horizontal structural complexity with little or no understory development, and relatively low wildlife habitat value, prescribed silvicultural treatments will be used to achieve the site-specific ecological objectives described in Section 5.2. Not all objectives will be achieved on all portions of the Project Area, but the treatments are expected to create and enhance structural heterogeneity, habitat value, and biological diversity.

5.2 Specific Ecological Objectives and Treatments

There are five management objectives for the Project Area. Associated with each objective is a number of silvicultural methods we will use to achieve the management objective (Table 4). Much of the Rex River basin was clearcut harvested by the 1970-80s, though one high quality patch of old-growth forest does remain at a higher elevation within the basin (Figure 2).

Because of the proximity to an existing old-growth habitat patch and the scarcity of older forest in the remainder of the basin, the primary goal for this project is to accelerate forest development over most of the Project Area in order to provide future late-successional forest habitat for old-growth dependent species. A secondary goal is to provide habitat in the near term for the numerous wildlife species that use the maturation stage but not the competitive exclusion stage.

Table 4. Proposed methods to achieve ecological objectives on 700 Road Forest Habitat Restoration Project Area.

Ecological Objective	Methods to Achieve Objectives
Maintain/Increase Tree Growth Rate	Thin to decrease competition
	Thin to increase light to individual tree canopies
	Create gaps to increase light to tree canopies at gap edge
	Leave trees in gaps to facilitate the growth of very large trees with large branch structure
Increase Species Diversity/Facilitate Understory Development	Thin to increase proportion of less frequent tree species
	Thin to increase light to forest floor, including removing some dominant and co-dominant tree canopy through snag creation
	Create canopy gaps
Increase Structural Complexity (Vertical and Horizontal)	Retain subdominant and understory trees
	Retain shrubs to extent possible
	Thin to increase light to forest floor (increase tree regeneration, shrub, herb initiation and growth), including removing some dominant and co-dominant tree canopy through snag creation
	Create canopy gaps/Leave some areas untreated
	Create leave areas to provide heterogeneity at the local forest scale
	Create different leave tree densities in the various ecological thinning units, to provide heterogeneity and mosaics of habitat patches at the local forest scale
	Leave trees in gaps to facilitate development of large trees (faster height growth, creating canopy roughness)
	Thin to accelerate tree growth (create emergent trees, creating canopy roughness)
Increase Number Snags/Facilitate Maintenance/Recruitment of Large Diameter Snags and Down Wood	Retain existing snags
	Retain existing DW
	Create snags in forest matrix (supplement for cavity nesting species in near term)
	Create snags in gaps (supplement for cavity nesting species in near term)
	Create DW in gaps and leave tops from snag creation (supplement for DW dependent species in near term)
	Leave all deciduous trees/true firs (become snags/DW in medium term)
	Create leave units and small untreated skip areas within thinning units to provide continued small snag recruitment through competition mortality
	Thin to accelerate tree growth (large diameter snags and DW in long term)
	Leave dominant trees in gaps (create large trees/large diameter snags and DW in long term)
Protect/ Enhance Special Habitats/Water Quality	No thinning/entry within 200 feet of Rex River, on inner gorge slopes, wet areas along the inner gorge slope break, or potential unstable areas
	No ground-based equipment within 30 feet of streams
	Place large woody debris within stream channels

Objective #1: Maintain or Increase Growth Rate of Trees.

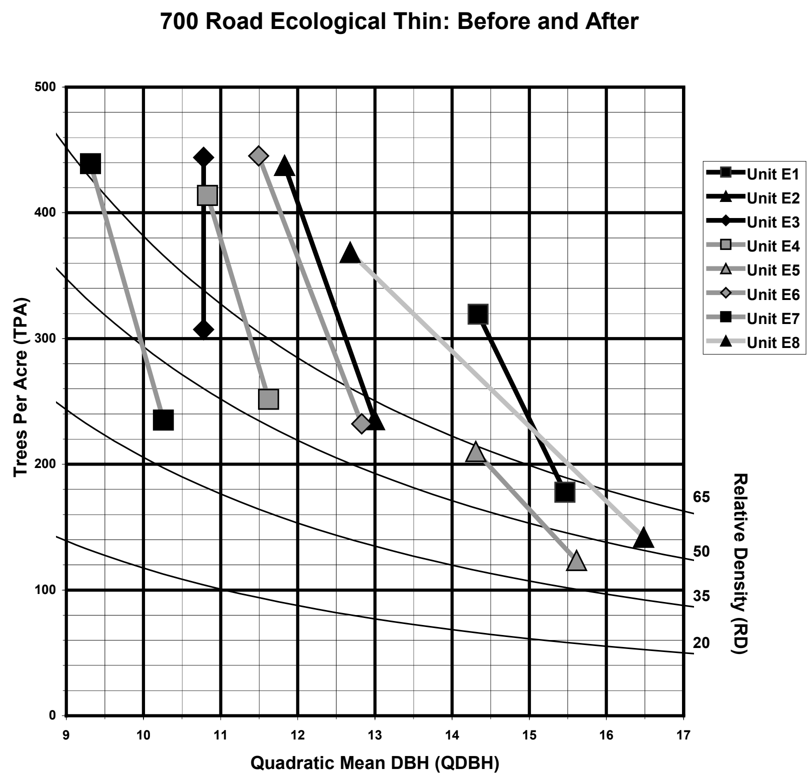
Competition for light, water, and nutrients has limited the growth rate and diameter of overstory trees on large portions of the Project Area, slowing the development of this habitat element. By reducing the density of overstory trees, the growth rate can maintain or increase rather than decrease, thereby accelerating the development of larger diameter trees (Smith et al. 1997). Ecological thinning will reduce the current average density of ≥400 live trees/acre to 124-252 live trees per acre, depending on the Ecological Thinning Unit (see Section 6.2). This treatment will reduce competition and maintain or increase the growth rate of the remaining trees. Based on the diameter of legacy trees and stumps, we expect that a range of 30 to >60 inch dbh trees will eventually develop on the Project Area, depending on the site-specific conditions.

Extensive data exist on tree densities and growth rates in Douglas-fir forests in the western Cascades (U.S. Forest Service 1974). Relative density (RD) is an index of tree growth potential based on tree density, quadratic mean diameter (used in preference to the arithmetic mean because it has a stronger correlation to the actual volume occupied by trees), and a theoretical maximum tree density (Reineke 1933). Competition mortality predominates above RD65, with some competition mortality between 55 and 65, and a high frequency of conifer regeneration at RD 45 or less (Bailey 1996, Hayes et al 1997). The site is considered no longer completely forested below RD20. We utilized RD as a tool to aid us in calculating the tree retention density required to achieve the ecological objective of maintaining or increasing tree growth, calculating RD based on Curtis (1982).

The ecological thinning treatment is designed to be conservative, decreasing the density to a point below RD65 at which growth rate should remain basically uninfluenced by competition for many years into the future, while still providing a sufficient number of trees to support future forest processes (Figure 6). This should contrast with unthinned areas, where growth rate is expected to decrease from continued competition. To ensure that larger diameter trees are retained on the Project Area, an upper diameter limit will be established, ranging from 12 to 19 inches dbh depending on the species and ecological thinning unit, above which no trees will be thinned. Some larger trees will be used for snag and DW creation in unit E3, however (see Section 6.2 for complete explanation). This upper diameter limit will allow us to significantly influence forest processes (e.g., increasing light to the forest floor, decreasing competition with neighboring trees) while still maintaining sufficient numbers of larger trees for future large live tree, snag, and DW recruitment.

Large-diameter trees are characteristic of late-successional and old-growth forests. Cavities in large-diameter trees are required for nesting habitat by spotted owl. Marbled murrelet (*Brachyramphus marmoratus*) require large branches for nesting, habitat characteristics that generally develop only on large-diameter trees. The vertical structure provided by large emergent trees is important to certain bird species, such as the olive-sided flycatcher (*Contopus cooperi*) and several raptors. The deeply fissured bark that develops in older trees supports invertebrate communities, is used by bark-foraging birds such as brown creepers (*Certhia americana*), and is used as roosting sites for many species of bats. In addition, larger trees support a variety of lichens and fungi that are important food sources for many small mammals, including the northern flying squirrel (*Glaucomys sabrinus*), a major prey species for northern spotted owls (Johnson and O'Neil 2001).

Figure 6. Trees per acre, quadratic mean diameter, and relative density for ecological thinning units E1-E8 before and after thinning.



Objective #2: Increase Plant Species Diversity/Facilitate Understory Development.
Tree species diversity is already relatively high on the Project Area, with the presence of seven tree species. Most of the Project Area, however, is dominated by western hemlock and Douglas-fir. By thinning only the most abundant species, we will increase the relative proportion of less frequent species throughout the Project Area, resulting in higher diversity indices (Table 5). A variety of tree species with different timing of seed production provide a more stable and diverse food source for birds and small mammals than would a single species. In addition, different conifer and deciduous species provide a range of growth rates and bark surfaces that contribute to the complexity of the forest and biodiversity (Johnson and O'Neil 2001). Deciduous trees in particular host a high diversity of macrolichens and moth species, and are critical habitat elements for many bird species (Muir et al. 2002, Starkey and Hagar 2001). An array of both conifer and deciduous leaves on the forest floor provides litter important to many invertebrates, insectivores, small mammals, and amphibians, as well as contributes to nutrient and carbon cycling and soil development.

Understory development on the Project Area is extremely limited by the high canopy closure and resultant low light levels at the forest floor. Reducing the density of trees through thinning and removal of some selected dominant and co-dominant tree canopy through snag creation will allow more light to reach the forest floor, which should enhance initiation and growth of understory trees, shrubs, and herbs. Creating canopy gaps will also contribute to understory development by allowing shrubs and herbs with greater light requirements to colonize the Project

Area. A diversity of tree, shrub, and herbaceous species is characteristic of late-successional forests, and provides a wide range of habitat elements for native wildlife species. Berry and flower producing shrubs are essential habitat elements for several wildlife species, including rufous hummingbird (*Selasphorus rufus*), red fox (*Vulpes fulva*), and band-tailed pigeon (*Columba fasciata*). Deciduous foliage provides substrate for foliar insects that are a food resource for many bird and bat species. In addition, the presence of deciduous trees appears to be a key habitat element for several species of birds, including olive-sided flycatcher, Pacific slope flycatcher (*Empidonax difficilis*), and downy woodpecker (*Picoides pubescens*).

Table 5. **Change in percent tree species composition (number of trees) and diversity indices before and after ecological thinning, 700 Forest Habitat Restoration Project Area.**

	Percent Composition by Tree Species[1]								
Unit	WH	DF	RC	PSF	NF	RA	BC	Shannon-Weiner Diversity Index	Simpson Diversity Index
E1 (thin 35% BA[2])									
Before	56	11	26	4	1	2	0.3	1.20	2.58
After	46	12	27	8	1	4	1	1.40	3.26
E2 (thin 35% BA)									
Before	58	20	16	2	0.2	4	0	1.15	2.50
After	50	22	17	3	0.3	8	0	1.30	3.03
E3[3] (thin 30% BA)									
Before	50	32	10	8	0	0	0	1.15	2.73
After	50	32	10	8	0	0	0	1.15	2.73
E4 (thin 30% BA)									
Before	65	15	17	3	0	0	0	0.97	2.10
After	61	16	18	5	0	0	0	1.05	2.32
E5 (thin 30% BA)									
Before	56	43	1	0	0	0	0	0.75	2.03
After	55	43	2	0	0	0	0	0.78	2.08
E6 (thin 35% BA)									
Before	75	17	5	1	0	2	0	0.80	1.70
After	66	19	9	3	0	3	0	1.01	2.07
E7 (thin 35% BA)									
Before	60	32	8	0	0	0	0	0.87	2.14
After	53	34	13	0	0	0	0	0.97	2.42
E8 (thin 35%BA)									
Before	77	14	8	1	0	0	0	0.68	1.62
After	50	27	21	2	0	0	0	1.03	2.76

[1]WH = Western Hemlock, DF = Douglas-fir, RC = Western Red Cedar, PSF = Pacific Silver Fir, NF = Noble Fir, RA = Red Alder, BC = Black Cottonwood
[2]BA = Basal Area; See Appendix II for data on basal area for each tree species
[3]Removing canopy from all diameters, so no effect on percent composition

Objective #3: Increase Forest Structural Complexity.
A canopy containing large emergent trees and layers of dominant, co-dominant, intermediate, and suppressed trees, tall shrubs, short shrubs, and herbaceous vegetation provides vertical structural complexity that has not yet developed in the Project Area. Ecological thinning will reduce the tree density, create variable spacing, and create patches of tree density varying from 124 to 281 trees per acre in the ecological thinning units to ≥400 trees per acre in the three untreated leave units and the small untreated patches within the thinning units. The juxtaposition of denser areas in the leave units, with the varied leave tree densities and gaps created in the ecological thinning units simulates the variability seen in a natural forest, and will contribute to both biodiversity and heterogeneity at the local forest scale. Ecological thinning and selective removal of some dominant and co-dominant tree canopy through snag creation will increase the light level to the forest floor, which should facilitate tree, shrub, and herb establishment in the understory, leading to development of intermediate canopy layers and increasing vertical structural heterogeneity. Retaining emergent trees, trees with physical damage, existing snags, deciduous trees, and shade-tolerant conifers in the ecological thinning units will also contribute to structural complexity.

Horizontal structural complexity in late-successional forest is provided, in part, by canopy gaps created by natural small-scale disturbances and individual tree death. Spies et al. (1990) found that canopy gaps occupied 18.2 percent of mature Douglas-fir forests (80-200 years old) and 13.1 percent of old-growth forests in western Oregon and Washington. Many of these gaps were greater than 25 years old and were occupied by understory vegetation. They hypothesized that small gaps in younger developing forests are likely filled from horizontal branch growth of the dominant trees. Gaps in older forests are frequently created from large trees dying and falling. We will simulate these processes by creating small gaps during the ecological thinning, with the goals of increasing forest structure and light penetration from the gap into the adjacent thinned forest. Some larger gaps that should persist for prolonged periods and allow for shade intolerant tree regeneration, will also be created. A gap study in southern Washington found that Douglas-fir can regenerate in gaps as small as 1/3 acre (Anonymous 2002). In addition, small skip areas in which no thinning will take place will be created in the proximity of the gaps. The goal is to create small-scale heterogeneity and mosaics of habitat within the Project Area, including open areas in canopy gaps, various densities of open forest in the different ecological thinning units, and denser forest in untreated skip areas and leave units.

Structural complexity develops as the forest matures and is important for many species of wildlife, with different species utilizing different canopy layers. Ground foragers such as winter wren (*Troglodytes troglodytes*), spotted towhee (*Pipilo erythrophthalmus*), and most insectivores and rodents primarily use litter, DW, and herbaceous plants on the forest floor. Species such as Wilson's warbler (*Wilsonia pusilla*) and Douglas squirrel (*Tamiasciurus douglasii*) use low and intermediate shrub and overstory tree canopy layers for foraging and nesting, and species such as golden crowned kinglet (*Regulus satrapa*) and forest deer mouse (*Peromyscus keeni*) primarily utilize the upper canopy. Spatial heterogeneity, including both areas of high vertical diversity of vegetation and areas of sparse understory, provides the variety needed for species such as spotted owl to locate, track, and capture prey, as well as perches from which they can pounce (Carey et al. 1999).

Objective #4: Increase Number of Snags in Short-term; Facilitate Recruitment of Large-diameter Snags and Down Wood in Medium and Long term.

Large volumes of large-diameter standing and down dead wood are key characteristics of old-growth forests. Spies and Franklin (1991), in a study of naturally regenerated forests, found that mature forests (80-195 years) average six large diameter (>19.5 inches dbh) snags per acre, with a total of 40 snags of all sizes per acre. Snags and DW are generally not evenly distributed across old-growth forests, but often occur in patches. There are few snags in the Project Area, and no cutting of larger diameter snags will occur. It is possible during the thinning operation that an occasional small snag may need to be cut in order to protect worker safety and to comply with Washington State Department of Labor and Industry safety requirements. If this occurs, the wood will be retained on site as DW. In addition, we will create larger snags in the forest matrix in all ecological thinning units, as well as in the gaps (see Section 6.2).

Maintaining the three leave units and 12 untreated skip areas as no-cut zones during the ecological thinning will allow continued small snag and DW recruitment through competition mortality. Once the snags fall, they will function as DW on the forest floor, providing wildlife habitat and enhancing soil formation. Ecological thinning should facilitate more rapid development of large-diameter trees, and therefore recruitment of large-diameter snags over the long-term, as trees die through natural processes such as windthrow, lightning, and insects. Retention of short-lived deciduous and true fir species and trees with physical damage will also contribute to snag recruitment in the intermediate term. It is expected that snags will continue to occur in patches across the Project Area, a pattern that is seen in naturally functioning forest ecosystems.

All existing DW will be retained on the forest floor during ecological thinning. Additional large DW within the forest will not be created at this time because the volume of DW from the 1992 data was much higher than the range of DW found from 19 old-growth plots in the CRMW. The 1992 plots from portions of the 700 road site had an average DW of 5,352 ft^3/ac, compared with a range of 62-1,460 ft^3/ac in the old-growth plots (Mason, Bruce, and Girard 1992, unpublished data 2003). Although the 1992 plots were limited, they do indicate that high density patches of DW occur on the site, which is consistent with the pattern observed throughout the Project Area in 2002. There is a wide range of sizes of existing DW that will decay at varying rates, providing soil enhancement throughout long time frames. Creating even more DW could create a situation where understory plants have insufficient ground substrate, inhibiting rather than enhancing this important habitat and structural element (ecological objective #2). We will create additional large diameter DW in the larger gaps, that will simulate a naturally functioning forest, where small gaps are usually created by single or a small clump of trees falling, leaving DW present in the gap. We will also leave a few dominant trees in the larger gaps, where growth conditions should be favorable, creating a large tree, and eventually a large diameter snag. In addition, smaller diameter DW will be enhanced by retaining the tops of all created snags, as well as the branches from thinned trees. This smaller diameter DW should provide soil enhancement in the short term.

Snags are a vital habitat component for many wildlife species, ranging from cavity excavating species such as woodpeckers, to secondary cavity users, including several owl species (Thomas et al. 1979). Numerous bat species use large-diameter snags, especially at more advanced stages of decay (Christy and West 1993). Loose bark provides both day and night bat roosting sites, and cavities provide a stable microclimate for maternity colonies. Down wood, especially large-diameter logs, is used by numerous wildlife species, including amphibians, many small carnivores, and a myriad of insect species (Spies and Cline 1988). A large log is a primary growth substrate for many species of fungi and plant species (e.g., the "nurse log" phenomenon) (Cowling and Merrill 1966, Maser et al. 1988). Down wood is also crucial for carbon and nutrient cycling and water retention (Harmon et al. 1986). Although large-diameter snags and DW (>30 inches dbh) are more persistent and can be used by a greater variety of wildlife species, smaller wood is still used by many species.

Objective #5: Protect/Enhance Special Habitats and Water Quality.
Many species of fish, amphibians, and invertebrates are sensitive to increased sedimentation and temperature. Our objective is to protect both the in-stream habitat, as well as municipal water quality. Environmental impacts to the Rex River were avoided by placing the Project Area boundary upslope of the inner gorge slope break, wet areas along the inner gorge slope break, and potential unstable areas. This resulted in the Project Area being ≥200 feet from the Rex River.

The three small streams and their associated wetland and seep areas will have no deciduous trees cut from within the riparian zone. In addition, all conifer trees will be left that have any part of their canopy projecting over the maximum bankfull width of the main or any secondary channel or associated wetland or seep. No ground-based equipment will be brought within 30 feet of the bankfull width of the channel, and there will be no yarding over stream channels unless there is no ground or canopy disturbance (i.e., no logs will be dragged through a stream channel). Some conifers will be thinned from within the riparian zone to accelerate forest development near the stream, particularly the growth of conifers to eventually provide large DW. The trees within the riparian area that will be thinned will be felled directionally away from the channels. In addition, some trees will be felled across and left within the stream channels to enhance current in-channel habitat.

6.0 SPECIFIC THINNING TREATMENTS

To achieve the management objectives (Section 5.1), the Project Area (481 acres) was divided into 12 units based on ecological variables such as current tree density, tree diameter, and hill slope (Figure 1). In order to create diversity and a mosaic of habitats across the Project Area, eight of the units (E1-8 = 395 acres) were designated as likely to benefit ecologically from thinning. One unit will be restoration thinned (14 acres) and three of the units (72 acres) were designated as untreated leave units, which will not be thinned. The leave units were designed to include denser patches within the management area to achieve heterogeneity on the local forest scale. Although these units are not technically controls (i.e., they were not randomly selected), they are very similar to the thinning units and will serve as areas with which the results of the ecological thinning can be compared. The untreated leave units are expected to maintain slow growth rates of overstory trees, support limited understory development, and recruit small snags as a result of competition mortality. The units designated for ecological thinning required customized thinning treatments based on existing forest composition and the goal to increase forest structural complexity on multiple spatial scales.

6.1 Data and Scenarios Considered

During development of the final thinning treatments we evaluated a range of data and potential scenarios. In order to predict tree growth response, we calculated RD (defined in Section 5.2), basal area, and height to diameter ratios (see the following paragraphs for explanation). Basal area, which sums the cross-sectional area of all trees at dbh by species over a given area, is a calculation that has been used extensively in tree growth and growth response to thinning research (Curtis and Marshall 1989). Based on extensive professional experience thinning similar forests, we considered 25, 30, and 35 percent basal area removals as the range of reasonable targets that would most appropriately affect the ecological processes in the forest, but would not entail significant risk of windthrow in this area that typically experiences strong winds. Removing more than 35 percent of the basal area would put the Project Area at relatively high risk of windthrow (U.S. Forest Service Silvicultural Institute, pers. comm.). The project team calculated the number of trees per acre that would be retained under each basal area target using a variety of tree species in the thinning pool. We evaluated a wide range of potential thinning pools (using different tree species and diameters), with various maximum diameter limits. We also considered effectively thinning across all diameters by removing some larger diameter trees through snag creation.

Ecological thinning will move all eight ecological thinning units away from competition mortality (e.g., the maximum tree density curve of RD 65) to a tree density that will facilitate a higher rate of growth (Figure 6). We calculated the relative density that would be achieved with the various basal area removals and different maximum diameter thinning limits. Our goal was to reduce the relative density below 60-65. The relative density for optimal tree growth ranges from 35 to 55, a range in which the trees are far enough apart that they are unaffected by competition for light, water, and nutrients (U.S. Forest Service Silvicultural Institute, pers. comm.). This range should also provide sufficient light to the forest floor to promote understory development and shade-tolerant tree regeneration. We were able to reduce the relative density to a range that is optimum for tree growth only for units E5, E7, and E8 because of the increased risk of windthrow. We were able to reduce RD below 65 for the remaining units, however, which will significantly affect tree growth and the light regime on the forest floor, while still allowing some mortality to occur.

The average tree height to diameter ratio can indicate the amount of wind firmness of the forest. Tall trees with small diameters have much less root structure than shorter trees with larger diameters. Trees that grow in close proximity to each other are unable to develop the crown and root structure that enable them to resist strong winds. Trees that grow in more open environments develop large crown and root structures, and have a smaller height to diameter ratio. Wonn and O'Hara (2001) found that trees in western Montana with a height to diameter ratio of more than 80 were more susceptible to windthrow than those with lower ratios. We had no equivalent data for the western Cascades, so used a conservative ratio of 70 as our target to reduce the risk of windthrow (R. Curtis, emeritus scientist, USFS, pers. comm.). We calculated two ratios for each ecological thinning unit: 1) using all trees within the unit, and 2) using only the most dominant trees (those trees with diameters larger than our target thinning pool). Combining information on the height to diameter ratio, the quadratic mean diameter, and the relative density, allowed us to evaluate the risk of windthrow under each basal area removal scenario.

Forest growth models are useful for projecting current overstory tree growth in an even-aged forest stand. Because of the high level of uncertainty in applying these models to development of LSF characteristics, however, we have only used them for short-term overstory growth responses. We used the Forest Vegetation Simulator (FVS) and the Stand Visualization System (SVS) models, to help visualize the effect on the forest under various thinning scenarios. An example of the SVS results is presented in Figure 7, comparing current conditions (from the 2001 forest inventory data) with those projected seven years after thinning (year 2011, assuming thinning occurs in 2004) for each ecological thinning unit, using the basal area removal described in Section 6.2. The models predict that the thinning treatments will accelerate development of larger trees (QDBH >30 inches) 40 to 70 years faster compared with no thinning, depending on the initial conditions. The SVS results also portray some differences between treatments. For example, the results for E1, E3, E5, and E6 demonstrate the retention of vertical structure (a variety of tree heights), while E8 demonstrates creation of a single canopy layer by elimination of all understory trees. The models do not, however, include other important components of LSF (i.e., understory response, tree regeneration, snags, and DW). Unfortunately, none of these models will predict development of vertical structure from understory tree, shrub, and herb regeneration.

Potential number and placement of canopy gaps and untreated skip areas were evaluated by considering the slope and aspect while concurrently assessing the risk of windthrow. Gap sizes were designed to be large enough to influence key forest processes, to provide horizontal structural complexity, and to allow some shade intolerant tree regeneration. We will monitor the effects of a range of sizes of small gaps on understory plant and tree initiation and use the data in adaptive management to guide planning of future ecological thinning projects.

We considered a range of snag creation techniques, including girdling at breast height, crown girdling, top blasting, saw topping, limbing, and fungi inoculation (see Appendix IV for a complete description of the techniques considered, with their associated costs). Snags will created after the thinning is complete and decisions on techniques will be made at that time based on safety, logistics, reported success, and cost. A number of different techniques will be utilized, however, to provide a staggered entry of snags into the ecosystem. In addition, different tree species and sizes will be used for snag creation (see Appendix II for the pool of trees to be used for snag creation by ecological thinning unit), to provide a variety of habitat for different wildlife species.

6.2 Thinning Treatments

The primary data we used in developing the final treatments and determining the final target thinning pools were number of trees per acre, dbh, basal area, relative density, quadratic mean diameter, height to diameter ratio, and tree species (Tables 6 and 7). Examining relative density, height to diameter ratio, and quadratic mean diameter, combined with years of professional experience allowed us to evaluate the risk of windthrow for each unit. We varied the basal area removal and leave tree density among the units to achieve both stability from windthrow and to create a diversity of patch types at the local forest scale.

Figure 7. Results of Stand Visualization System forest growth model for units E1-E8, before thinning and seven years post-thinning. Note: the inventory data are from the 2001 forest cruise and the anticipated thinning will occur in 2004. The term 'beginning of cycle' refers to the beginning of the growing season in 2011.

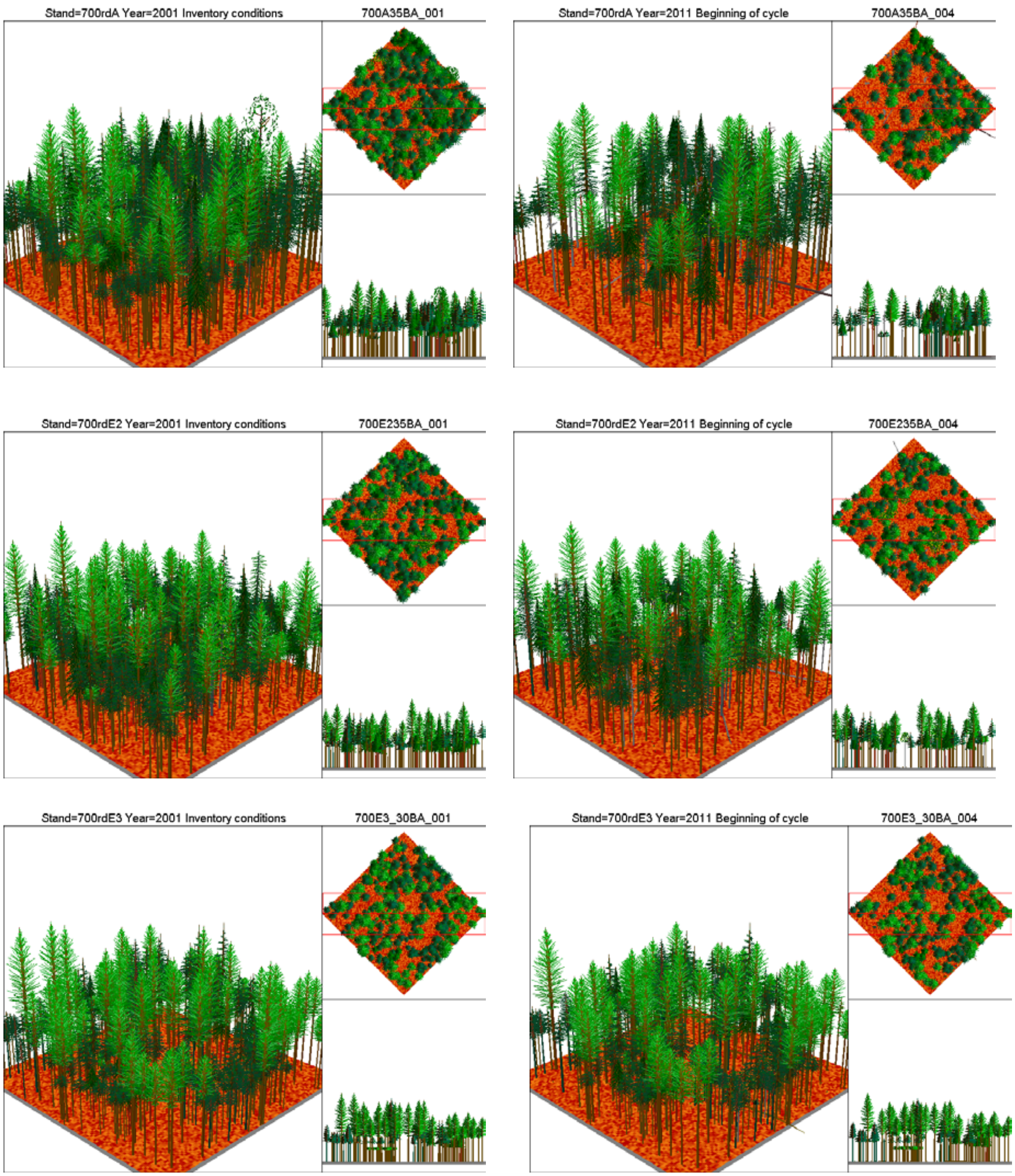


Figure 7 (cont.)

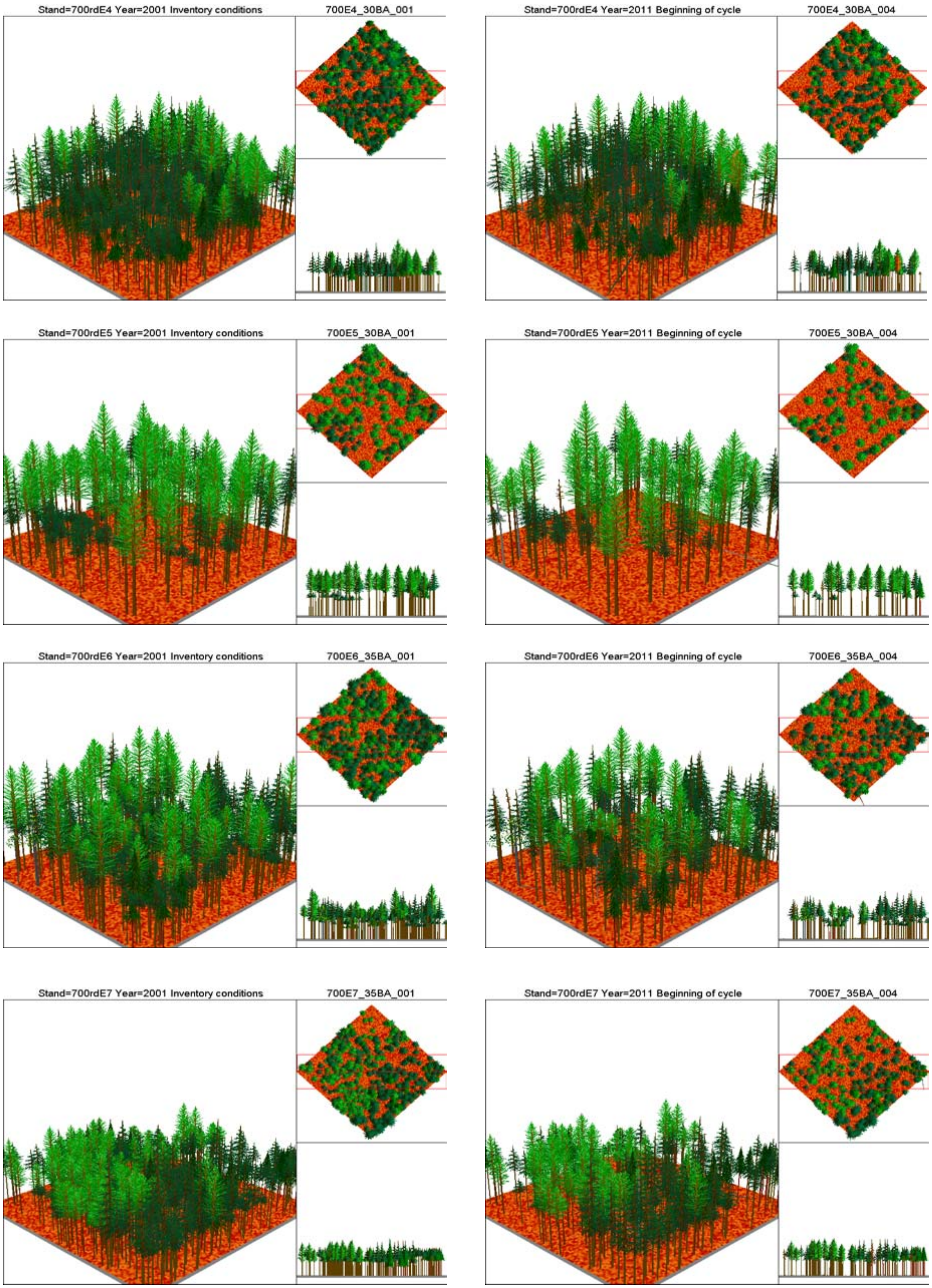
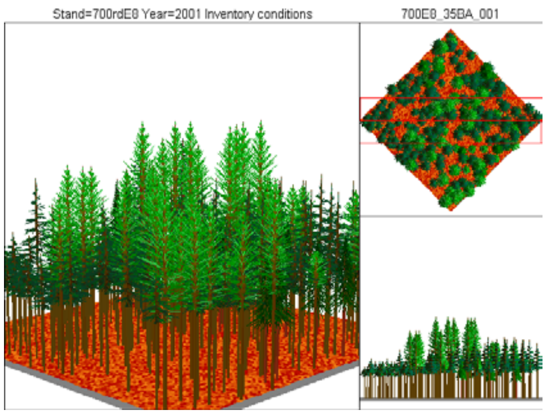
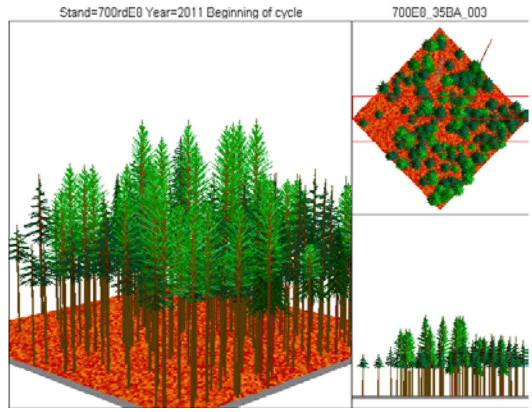


Figure 7 (cont.)





The target thinning pool includes only the most prevalent species (Douglas-fir, western hemlock, and some western red cedar), retaining all deciduous and other minor conifer tree species. In addition, upper diameter limits for thinning were created in all ecological thinning units, to ensure that sufficient numbers of larger diameter trees would be retained (see sections 6.2.1 – 6.2.9 for specific limits for each unit).

Some trees of all diameters within the target thinning pool will be cut, with all trees outside the target pool retained (Appendix II). The marking/selection guide (delineating which trees within the target pool will be cut) will be applied as if the leave (non-target) trees did not exist, which will result in both variable spacing between trees and a large variety of tree diameters and heights retained within the unit. Application of this treatment will simulate the heterogeneity seen in more natural forest development. If cable yarding occurs in any unit, the cables will not be run through the live crowns of the dominant or co-dominant overstory, to avoid damage to these trees. The number of residual trees and residual square feet of basal area per acre are the key variables for measuring operator compliance. A detailed marking and harvest guide was developed for each ecological thinning unit to enable contractors to accurately follow the prescription without the necessity of marking trees prior to thinning (Appendix V). The guide was reviewed by several experts, all of whom agreed that it achieves that goal. CRMW staff will mark both trees to be retained and trees for snag creation in units E1 and E3 (and potentially more units, if needed), however, in small training areas of approximately three acres each. These training areas will be used by potential contractors as an aid in interpreting the marking and harvest guide.

Although the ecological thinning is not designed as a formal research experiment, we are using the site as part of adaptive management learning. This site will help us learn about the effects of different thinning techniques (leave tree density, size of trees thinned, species composition of leave trees, removal of only small trees versus removal of some dominant tree canopy through snag creation), how different sizes of canopy gaps contribute to forest structural complexity and affect forest processes, and the effect of different harvest systems and snag creation techniques. This type of information will help us to design more effective restoration projects using silvicultural treatments in the future.

Table 6. Summary of current and post-thinning conditions for the eight Ecological Thinning Units.[1]

Characteristic		Ecological Thinning Unit							
		E1	**E2**	**E3**	**E4**	**E5**	**E6**	**E7**	**E8**
Number of Acres		80	92	47	21	36	85	19	15
Target thinning pool[2]		WH≤19", DF≤19", RC 6 and 10-17"	WH ≤15", DF ≤17", RC≤15"	WH≤17", DF≤17", RC≤17", PSF≤17"	WH≤13", DF≤15", RC≤10"	WH≤11", DF≤19"	WH≤14", DF≤17", RC11-15"	WH≤10", DF≤10", RC 8-12"	WH≤13", DF≤13"
Basal Area (ft^2/ac)	Percent removal, entire unit	35	35	30	30	30	35	35	35
	Current live trees	358	334	278	265	235	321	208	323
	Leave live trees	232	217	192	185	164	208	135	210
Trees Per Acre	Current live trees	319	438	407	414	210	445	439	369
	Leave live trees[3]	178	235	281	252	124	232	235	142
Relative Density	Current live trees	95	97	86	80	62	95	68	91
	Leave live trees	59	60	59	54	42	58	42	52
Quadratic Mean Diameter (inches)	Current live trees	14.3	11.8	11.2	10.8	14.3	11.5	9.3	12.7
	Leave live trees, entire unit	15.5	13	11.2	11.6	15.6	12.8	10.3	16.5
	Leave live trees, largest dominants	18.8 (93 trees >15" dbh)	19.1 (59 trees >16" dbh)	17.8 (51 trees >15" dbh)	15.8 (68 trees >14" dbh)	19.9 (60 trees >15"dbh)	18.6 (72 trees >15" dbh)	13.5 (89 trees >11" dbh)	18.1 (85 trees >15"dbh
Height/ Diameter Ratio	Current live trees, entire unit	72	76	75	86	70	83	81	74
	Current live trees, largest dominants	58	61	66	70	62	64	66	69
	Leave live trees, entire unit	63	66	71	73	65	67	75	71
	Leave live trees, largest dominants	60	61	65	66	62	63	67	69
Snags	Current snag/acre	1	2	8	0	0	0	0	0
	Number snags/acre to be created	4	4	12	4	4	4	4	4
	Snag creation pool	WH&DF 15-19", RC 15-17"	DF 14-17", WH&RC 14-15"	All species ≥15"dbh	WH 11-13", DF 11-15"	DF 15-19"	DF 14-17", WH 14", RC 14-15"	WH&DF 10", RC 10-12"	WH & DF 10-13"

[1] Data are for all trees ≥ 6 inches dbh, from 2001 forest inventory
[2]WH = Western Hemlock, DF = Douglas-fir, RC = Western Red Cedar, PSF = Pacific Silver Fir
[3]Numbers are estimates and may not agree exactly with numbers in Table 7 due to rounding

Table 7. Density of trees (per acre) by species before and after ecological thinning.[1,2]

Thinning Unit	Current Tree Species	Number Before Thinning	Projected Number Thinned	Projected Number After Thinning
E1	Western Hemlock	177	95	82
	Douglas-fir	34	12	22
	Western Red Cedar	83	34	49
	Pacific Silver fir	14	0	14
	Noble fir	2	0	2
	Red Alder	8	0	8
	Black Cottonwood	1	0	1
	Total Live	319	141	178
E2	Western Hemlock	252	135	117
	Douglas-fir	87	35	52
	Western Red Cedar	72	33	39
	Pacific Silver fir	7	0	7
	Noble fir	1	0	1
	Red Alder	19	0	19
	Total Live	438	202	235
E3	Western Hemlock	204	63	141
	Douglas-fir	129	40	89
	Western Red Cedar	42	13	29
	Pacific Silver fir	32	10	22
	Total Live	407	125	281
E4	Western Hemlock	269	116	153
	Douglas-fir	63	22	41
	Western Red Cedar	70	24	46
	Pacific Silver fir	11	0	11
	Total Live	414	162	252
E5	Western Hemlock	118	50	68
	Douglas-fir	89	37	53
	Western Red Cedar	3	0	3
	Total Live	210	87	124
E6	Western Hemlock	332	178	154
	Douglas-fir	76	31	45
	Western Red Cedar	24	4	20
	Pacific Silver fir	6	0	6
	Red Alder	7	0	7
	Total Live	445	213	232
E7	Western Hemlock	263	138	125
	Douglas-fir	142	62	80
	Western Red Cedar	34	4	30
	Total Live	439	204	235
E8	Western Hemlock	284	214	70
	Douglas-fir	52	13	39
	Western Red Cedar	30	0	30
	Pacific Silver fir	3	0	3
	Total Live	369	227	142

[1] Data are for all trees $\geq$ 6 inches dbh
[2] Basal area for each species by each diameter can be found in Appendix II.

We determined that the risk of windthrow would be too high if we created gaps on units with steep slopes. Consequently, only those units with the gentlest slope will have gaps created within them (E1, E2, and E8). We will create 12 gaps (five each of ¼-acre and ½-acre, and two ¾-acre) that were randomly assigned within these Thinning Units. Associated with each canopy gap will be an untreated skip area of the same size, to provide structural complexity and within-patch heterogeneity. Untreated areas will be placed, whenever possible, around existing large diameter snags, DW, or streams. See Section 6.2.2 for a complete discussion of the gaps and untreated skip areas.

If possible, all existing snags will be left in place. If any snags need to be cut for safety purposes, however, they will either be topped as high as possible with the top left on site, or cut and left in place as DW. The safety decision is at the sole discretion of the operator. If, during the operation, a large snag (>30 inches dbh and 30 feet tall) is discovered, it will be reported to the compliance officer. SPU staff will then evaluate the snag and its relative ecological significance, make a decision on whether or not to retain it or use it for DW, and if retained, determine an appropriate means to protect the snag and ensure operator safety. The Contract Administrator will work with the Contractor to modify the contract to find supplemental trees elsewhere in the Project Area or to compensate for any additional costs to the operator if additional trees are left to protect the snag.

In addition to retaining existing snags, four snags per acre will be created throughout the Project Area, with a higher density of 12 snags per acre created in E3. The trees for snag creation will be selected from the larger trees within the target thinning pool and marked prior to the thinning (Table 6). A range of sizes within the snag creation pool was used to both provide different snag decay rates and to allow flexibility in selecting the trees. Multiple tree species will be used for snag creation within each unit, to provide a variety of decay rates. If possible, created snags will be clumped within each unit, rather than evenly distributed, to simulate natural patterns and to facilitate future thinning entries, if needed. For safety reasons, no snags will be created within 1.5 times the snag height from an active road. Snag creation will occur after ecological thinning is complete, and will use a variety of the techniques discussed in Section 6.1. Different techniques will cause different rates of tree mortality and different expected snag longevity, providing a variety of wildlife habitat over the short term. The trees for snag creation will be marked during the thinning operation (Appendix V). A separate contract will be developed for the actual snag creation.

No existing DW will be removed from the Project Area. Logs up to 30 inches diameter may be bucked only if they significantly interfere with the thinning operation. If large diameter logs (>30 inches diameter) are discovered, the operator will report it to the compliance officer. WMD staff will then assess the ecological significance of the log and evaluate alternatives for maintaining the integrity and functionality of the piece.

6.2.1 Ecological Thinning Unit 1 (E1)

Ecological Thinning Unit 1 (80 acres) is a long narrow area with gentle slope, located between the 700 road and the Rex River (Figure 1). It is located on a southerly aspect, oriented generally northeast to southwest, with an elevation range of approximately 1,800 to 1,960 feet asl. This unit contains portions of the two ephemeral streams that flow into the Rex River, both of which are surface dry for much of the year. In general, the ephemeral channels in Unit E1 (that extend into Units E6 and E7) tend to be steep (generally >20%) boulder-dominated cascade channels within which riparian vegetation plays a limited role in overall morphology. Although in-channel LWD levels are low throughout these units and existing wood is generally highly decayed, the potential for LWD to promote significant sediment storage is limited by tight channel confinement and high transport capacities. In addition, no chronic bank erosion or slope stability issues were observed in any of these streams, reflecting the relative insensitivity of key aquatic processes to past timber harvest practices.

Although these channels have not exhibited dramatic changes following past management, the following thinning prescriptions have been developed to ensure protection and promote restoration of key processes:

- Leave all trees that have any portion of their canopy extending over the bankful channel width of the main or any secondary channel or associated wetland or seep.
- Ground-based equipment will be excluded within 30 feet of the channel.
- No yarding corridors will cross the stream, and any logs that might need to be yarded through the riparian area will be fully suspended, ensuring no ground disturbance.
- No deciduous trees will be thinned.
- One source tree (14 to 17-inch diameter conifer) will be directionally felled toward the channel approximately every 100 feet. Felled trees (using tree species and sizes from the snag creation pool, see Table 6) will be from within 50 feet of the channel.
- Any part of the tree falling within ten feet of the bankfull edge will be left in place, although portions of the tree falling in the upland may be removed.

The intent of felling one 14 to 17-inch diameter conifer every 100 lineal feet into these streams is to improve short-term sediment storage processes over the period it will take to restore natural stand mortality processes and rates adjacent to these streams. Additionally, the LWD will improve the aquatic habitat for invertebrates and other stream biota. With respect to the maintenance of bed and bank stability, the retention of all trees within the drip-line of the stream, and hence with roots likely reaching the stream banks, should ensure short-term bank stability. The thinning of adjacent trees should result in long-term improvements in bank stability triggered by more vigorous root networks from larger trees and enhanced LWD recruitment.

Because of its slope position, flat gradient, and adjacency to the Rex River, E1 has a deeper soil profile, and therefore higher growth potential, than the rest of the Project Area. E1 has a greater number of large diameter trees and more understory development than the other ecological thinning units.

The unit currently contains a basal area of 358 square feet and a relative density of 95 (Table 6). Removing 35 percent (126 ft^2) of the basal area will reduce the relative density to 59, which is higher than ideal to promote maximum tree growth response. A relative density of 35 to 55 would result in optimal growth rates of the residual trees and provide better conditions for understory initiation and seedling establishment. A conservative prescription is justified, however, because this will be the first entry into the forest and there will be a significant risk of windthrow. A relative density of 59 will allow the forest to develop structural stability by allowing the crown and root structure to expand, therefore creating more stability against wind. The current average height to diameter ratio of all live trees is 72, which demonstrates the high degree of interdependence the smaller trees have for wind firmness. The largest trees in the forest (80 trees greater than 15 inches dbh) have an average height to diameter ratio of 58, suggesting that these dominant and co-dominant trees are already relatively wind firm (i.e., the ratio is much less than 70). The fact that the quadratic mean diameter of the largest dominant and co-dominant trees is 18.8 inches supports the conclusion that these larger trees are likely wind firm. The residual smaller trees have a height to diameter ratio of 86, indicating this component of the forest is much more susceptible to windthrow. But the conservative residual relative density of 59, combined with the wind-firm larger trees, suggests that the ecological thinning should not increase windthrow. The post-thinning height to diameter ratio will be 63, indicating the entire unit should remain wind-firm.

The project team used the current tree density and distribution (Tables 6 and 7; Appendix II) to establish a target pool (pool of trees from which some trees can be harvested) of western hemlock ≤19 inches dbh, Douglas fir ≤19 inches dbh, and western red cedar either 6 inches or 10-17 inches dbh. Seven to nine inch diameter western red cedar will be retained to provide both species and vertical structural complexity. All larger trees will be retained. This pool of trees was chosen for thinning because the heights of 16-19 inch dbh trees indicate they are co-dominants, and a percentage of the co-dominants need to be removed in order to affect the forest processes of interest, especially the light regime on the forest floor. In order to promote within unit tree species diversity, all other tree species, including Pacific silver fir, noble fir, red alder, and black cottonwood, will be retained. The current 319 live trees per acre will be reduced to 178 live trees per acre by removing approximately 95 western hemlock, 12 Douglas-fir, and 34 western red cedar per acre, thinning across all diameters within the thinning pool. Leaving the larger diameter trees and thinning across all diameters of the target pool will result in a variable distribution of residual tree sizes and spacing.

The retained Pacific silver fir, noble fir, red alder and black cottonwood will provide species diversity, habitat variety, and vertical canopy structure. Pacific silver fir, a very shade tolerant species, can live for extended periods under the dominant canopy, providing intermediate layers of green canopy, and snags and DW over the long-term. We predict that the noble fir will not survive the competition beyond the short term because of its shade intolerance, providing snags and DW in the short and intermediate terms. The large red alder and black cottonwoods are short-lived, and are expected to die and provide snags and DW in the intermediate term, while providing current substrate for macrolichens. Once these species have died, they may create small canopy gaps, providing an opportunity for understory plant and seedling initiation, while increasing horizontal structural complexity.

We will create five gaps and leave five untreated skip areas in E1 to provide structural complexity and within-patch heterogeneity (Figure 1). See Section 6.2.2 for a complete discussion of the gaps created and untreated skip areas left in E1, E2, and E8.

6.2.2 Ecological Thinning Unit 2 (E2)

Ecological Thinning Unit 2 (92 acres) is located at the western end of the Project Area, and is bounded on the west by the junction of the 700 and 300 roads. This unit represents the toe of the ridge dividing the 300 and 700 road systems. The unit is generally flat, but does contain some north and south facing slopes on either side of the ridge, with a small amount of 20-25 percent slope along the ridge. The elevation ranges from approximately 1,880 to 2,160 feet asl.

This unit contains the only permanent stream in the Project Area, and the headwaters of one of the ephemeral streams (see Section 2.7). The perennial channel is moderately entrenched into consolidated alpine till. Boulders (from the till) as well as scant LWD currently form steps within this 4-6% gradient step-pool channel. Approximately 500 feet upstream of the 700 road, the channel is unentrenched and slopes decrease to a gradient of 2-4%. In the upper reach, roots and small LWD seem sufficient to maintain natural channel processes. Overall stream power throughout this reach is low, reflecting the small drainage area and gentle gradient. No secondary or overflow channels were observed along this tributary. The presence of till in these gently sloping depressions result in relatively shallow groundwater and riparian vegetation dominated by cedar and deciduous trees.

In light of the above, thinning treatments within this riparian corridor will include all the measures described in E1 (above), in order to meet aquatic restoration objectives consistent with the CRMW Aquatic Restoration Strategic Plan (Bohl et al. 2004). In particular, within this perennial step-pool channel, our goal is to maintain and restore sediment storage and transport processes associated with wood-formed steps. As our interim objective in these streams is a function of stream gradient, our goal is approximately two steps per 100 meters or one step every 150 feet of stream. In order to achieve this objective, a conservative felling strategy of a tree every 100 feet was adopted. With respect to the maintenance of bed and bank stability, the retention of all trees within the drip-line of the stream, and hence with roots likely reaching the stream banks, should ensure short-term bank stability. The thinning of adjacent conifer trees should result in long term improvements in bank stability triggered by more vigorous root networks and enhanced LWD recruitment. The upper portion of the ephemeral stream within this unit has some small headwater wetlands that will be protected using the measures as described in E1.

Thirty-five percent (117 ft^2) of the current basal area will be removed (Table 6). Approximately 135 western hemlock, 35 Douglas-fir, and 33 western red cedar per acre will be harvested from the current 438 trees per acre, retaining a tree density of roughly 235 live trees per acre. The ecological thinning will reduce the relative density from 97 to 60. As discussed for E1, this is a higher than optimal relative density, but because this is a first entry into the forest, we believe it is the maximum amount that can be removed while protecting against windthrow. The largest trees in this unit have a height to diameter ratio of 61 and a quadratic mean diameter of 19.1 inches, suggesting these dominant trees should not be at risk from windthrow as a result of the thinning. The height to diameter ratio for the entire unit will be reduced from 76 to 66, indicating increased wind firmness for the entire unit as a result of the thinning.

A target thinning pool for this unit of western hemlock $\leq$15 inches dbh, Douglas-fir $\leq$17 inches dbh, and western red cedar $\leq$15 inches dbh best meets the ecological objectives (Table 7). All larger trees, as well as the Pacific silver fir, noble fir, and red alder, will be retained to provide species diversity, canopy structure, and future snag and DW recruitment (as discussed for E1). The target pool includes some trees from the co-dominant canopy, which will allow increased light to reach the residual trees as well as the forest floor, encouraging understory plant initiation and tree regeneration. The additional light to the dominant canopy will cause the crowns to expand, both in depth and width. This will accelerate annual radial growth (increasing the diameter and expanding the root structure) which will help establish more stability against windthrow, as well as providing larger habitat trees in a shorter time frame. As with E1, leaving the larger diameter trees and thinning across all diameters of the thinning pool will result in a variable distribution of tree size and spacing among trees throughout the unit.

Canopy Gaps and Untreated Skip Areas (E1 and E2)
We will create 12 paired canopy gaps and untreated skip areas of three different sizes (¼, ½, and ¾ acres) in E1, E2, and E8 to add horizontal structural complexity to the Project Area and to simulate natural gap creation (Figure 1). Small gaps in mature forest are generally created through single or small numbers of large trees falling, creating a variety of gap sizes. The smaller gap sizes are designed to simulate this process. The larger ¾ acre gaps are designed to create horizontal structural complexity and to provide longer-lasting canopy gaps for understory plant initiation, intolerant tree species recruitment, and future forest complexity.

The circular gap/untreated skip area pairs were randomly assigned to the units. E1 will have two ¼ acre pairs, two ½ acre pairs, and one ¾ acre pair. E2 will have two ¼ acre pairs, three ½ acre pairs and one ¾ acre pair. E8 will have one ¼ acre pair. The different size gaps will have various numbers of live trees retained and snags and DW created within them (Table 8). The leave trees within the gaps will generally be the largest, healthiest trees available, though if a large live tree with a physical damage (i.e., broken top, multiple stem, visible conk) is available, it will also be considered for retention. Because of the increased light availability, these trees are expected to develop into large diameter trees with large branches.

The snags within the gaps will be created from the next largest available trees. The DW will consist of approximately 20-inch diameter logs selected from near gap edges, if available, and fallen into the gap. Priority for the largest trees within the gap will first be given to the live trees, next to the snags and finally to the DW creation.

Table 8. Amount of trees, snags, and DW in canopy gaps

Gap Size	Live Trees Left	Snags Created	Down Wood Created
¼ acre	0	0	0
½ acre	2	2	2
¾ acre	3	3	3

Approximate locations for each canopy gap and untreated skip area were randomly assigned (see Appendix V). SPU staff determined the final location for each gap and untreated area by considering tree species composition, density, diameter, presence of large snags or DW, topography, and probable harvest systems in the vicinity of the initial coordinate. Locations could shift up to 150 feet from the original coordinate, depending on local conditions. The untreated areas were located within a range of 150 to 300 feet from the paired gap. Both gaps and skip areas were marked with flagging, and their actual locations recorded with a global positioning system (GPS). The trees in the gaps for live tree retention, and snag and DW creation will be marked prior to the thinning. Other trees will be removed from the gaps. Untreated skip areas will be avoided during the thinning operation.

6.2.3 Ecological Thinning Unit 3 (E3)
Ecological Thinning Unit 3 (47 acres) is located adjacent to and east of E2, on the south side of the ridge that divides the 300 and 700 road systems. The unit faces primarily south with some

westerly aspect. Elevation in the unit ranges from 2,080 to 2,560 feet asl. There are no streams present in this unit. This unit is dominated by western hemlock and Douglas-fir, with small inclusions of western red cedar and Pacific silver fir.

The goal for this Thinning Unit is to investigate the ecological effects on the forest processes of tree growth, understory initiation, and seedling regeneration by removing a portion of the dominant and co-dominant tree canopy through snag creation (a method analogous to thinning across all diameters). Lindenmayer and Franklin (2002) recommend removing some dominant trees in order to adequately influence the light regime on the forest floor. We predict that this prescription will result in a marked increase in light to the forest floor that should greatly facilitate understory development, increase plant species diversity, and facilitate tree regeneration, all of which will contribute to increasing forest structural complexity. We are considering this as an experimental approach, and will monitor results. Because of the small acreage involved, and the number of larger trees retained (569 trees ≥20" dbh will remain in the unit after snag creation) it should entail low risk that insufficient larger diameter trees remain.

Based on a current live tree density of 407 live trees per acre (Table 6 and Appendix II), we will thin approximately 63 western hemlock, 40 Douglas-fir, 13 western red cedar, and 10 Pacific silver fir per acre. We will only remove trees ≤ 17 inches dbh from Unit E3 during the thinning process. The remainder of the canopy removal will be accomplished by creating approximately 12 snags per acre from a portion of all ≥15 inch dbh trees, removing the branches to ensure the light regime will be affected in approximately the same manner as if we removed the tree. Using all species to create snags will provide differing decay rates and longevity of the snags. The combination of thinning and snag creation will result in an effective basal area removal of 30 percent (86 ft^2) and a reduction of the relative density from 83 to 57. We are removing less basal area than in E1 and E2, and are not creating any gaps in E3 due to risk of windthrow. The height to diameter ratio of the largest dominant trees in E3 is 66. That, combined with the smaller quadratic mean diameter of 17.8 inches of these dominant trees, indicates that the dominant trees are somewhat less windfirm than those in E1 and E2. The residual relative density of 57, although higher than optimal, should provide good growing conditions in the near term.

We may use a variety of snag creation techniques (topping, blasting, girdling), as long as the canopy is removed (Appendix IV). Snags may be clumped or scattered throughout the unit, as the snag pool allows. If creation of all 420 snags is cost prohibitive, we may fell some co-dominant trees and leave them as DW. This prescription will allow us to learn about the relative effect on forest processes of removing some dominant and co-dominant tree canopy, plus having the additional benefit of creating a dense patch of larger diameter snags within a generally snag-deficient basin. There is currently an estimated density of eight western hemlock snags per acre in this unit, all <15 inches dbh. These snags will be retained to the extent possible during the thinning operation. If any snags need to be felled for safety reasons, they will be retained as DW. The high density of created and retained snags will provide habitat for cavity nesting species as well as future small gap creation and DW recruitment. This should introduce increased structural complexity into the forest as it matures, providing future canopy gaps for understory initiation, seedling recruitment, and increased tree growth for the residual trees.

6.2.4 Ecological Thinning Unit 4 (E4)

Ecological Thinning Unit 4 (21 acres) is located adjacent to and east of E2 and north of E3, on the north side of the main ridge. The unit faces north, and ranges from 2,200 to 2,560 feet in elevation asl. The slope is relatively steep, with gradients up to 40 percent. There are no streams on this unit.

There are smaller diameter trees on this unit than are seen on the south side of the ridge. The target thinning pool for this unit will be western hemlock ≤13 inches dbh, Douglas-fir ≤15 inches dbh, and western red cedar ≤10 inches dbh. All larger trees and Pacific silver fir will be retained to provide species diversity, canopy structure, and future snag recruitment. No other tree species were identified on this unit.

Thirty percent of the basal area of the current tree density of 414 live trees per acre (Table 6 and Appendix II) will be removed. Approximately 116 western hemlock, 22 Douglas-fir, and 24 western red cedar per acre will be harvested, retaining a tree density of roughly 252 live trees per acre. All thinning will be from below the dominant canopy layer. The relative density will be reduced from 80 to 54 by the thinning.

The largest 68 trees on this unit have a height to diameter ratio of 70 and a quadratic mean diameter of 15.8. Overall the leave trees will have a quadratic mean diameter of 11.6 inches. This spread of diameters indicates that the larger trees have begun to express dominance and have a reasonable degree of wind firmness. They do have a higher risk of windthrow than in E1 and E2, though 30 percent basal area removal should not entail much risk. No gaps will be created on this unit due to the elevated chance of windthrow. Thinning will lower the height to diameter ratio for all trees from 86 to 73, lowering the risk of windthrow. Additional thinning to reduce the relative density to 40-45 and to open the canopy to provide light for understory development will likely be needed on this unit after the trees have increased their crown and root structure.

6.2.5 Ecological Thinning Unit 5 (E5)

Ecological Thinning Unit 5 (36 acres) is located adjacent to and east of E3, on the south side of the main ridge, extending from the 700 road to the ridge top. The elevation ranges from 1,940 to 2,600 feet asl, with slopes up to 45 percent. There are no streams on this site. This unit was logged approximately two years after units E1-E4, so the trees are somewhat younger than in the previous units.

This unit has the lowest tree density (210 trees per acre) and relative density (62) on the Project Area. It is dominated by western hemlock and Douglas-fir, with a very small amount of western red cedar, and no other tree species found during the 2001 forest cruise. The goal for this unit is to reduce the relative density to an optimal level (42) to provide the best growing environment for the remaining trees and light for understory development. This unit will provide a patch of relatively open forest within the Project Area, creating structural complexity at the local forest scale.

The target thinning pool will be western hemlock ≤11 inches dbh and Douglas-fir ≤19 inches dbh. All western red cedar will be retained. The height to diameter ratio of the dominant trees

(62) and their quadratic mean diameter (19.9 inches) indicate that the dominant trees are already windfirm. As a result, we will remove thirty percent of the basal area or approximately 50 western hemlock and 37 Douglas-fir per acre, retaining a tree density of roughly 124 live trees per acre. Because of the steep slope and open forest structure, no gaps will be created on this unit.

6.2.6 Ecological Thinning Unit 6 (E6)

Ecological Thinning Unit 6 (85 acres) is located adjacent to and east of E5, on the south side of the main ridge, extending from the 700 road to the ridge top. It faces generally south, and contains slopes up to 50 percent, with elevation ranging from 2,160 to 2,760 feet asl. One ephemeral stream runs throughout the center of the unit. Protection and LWD enhancement for this stream will be the same as described for the stream segments in E1.

The current tree species composition is 75 percent western hemlock, 17 percent Douglas-fir, 5 percent western red cedar, and 3 percent true firs and deciduous trees. E6 has a high current relative density of 95 which, combined with a low quadratic mean diameter of all trees of 11.5 inches, represents a forest with high competition between the numerous small diameter trees. The current height to diameter ratio is 83 and canopy cover is almost 100 percent. The initial live tree density of 445 trees per acre will be reduced to 232 trees per acre by removing 35 percent of the basal area, or approximately 178 western hemlock, 31 Douglas-fir, and four western red cedar per acre. This will reduce the relative density to 58.

The target thinning pool will be western hemlock ≤14 inches dbh, Douglas-fir ≤17 inches dbh, and western red cedar ≤15 inches dbh. All larger trees and other tree species (Pacific silver fir and red alder) will be retained to provide species diversity, canopy structure, and future snag recruitment. The height to diameter ratio of the larger trees (64), and the quadratic mean diameter of these larger trees (18.6 inches) indicate that these trees have already expressed dominance and should be relatively wind firm. This means that a 35 percent basal area removal should not incur significant risk of windthrow to the dominant trees. Thinning will reduce the height to diameter ratio for all trees in the unit from 83 to 67. Because of the steep slope and risk of windthrow to the smaller diameter trees, no gaps will be created on this unit.

6.2.7 Ecological Thinning Unit 7 (E7)

Ecological Thinning Unit 7 (19 acres) is located north of E6, largely on the north side of the main ridge. This portion of the ridge is broad and represents the highest elevation in the Project Area, with a range of 2,640 to 2,840 feet asl. This unit was logged most recently (circa 1934), so the trees here are several years younger than in E1 and E2. This elevation is in the transition zone between the western hemlock and Pacific silver fir zones, although the species composition indicates it still lies in the western hemlock zone (Franklin and Dyrness 1988). A small portion of the ephemeral stream that flows through E6 is present. The channel becomes unconfined in E7, is less distinct, and is flanked by numerous seeps. The same stream protection measures described previously apply to this stream segment and the associated seeps.

This unit has the lowest site class designation (Site Class IV) in the Project Area (Table 1). Because of the poorer growing site quality, higher elevation, and younger age, the trees in this unit are smaller than the remaining ecological thinning units, averaging 9.3 inches dbh. The current relative density of 68 is a function of the large number of small diameter trees on the unit.

The target thinning pool consists of western hemlock ≤10 inches dbh, Douglas-fir ≤10 inches dbh, and western red cedar 8-12 inches dbh. No other tree species were detected on this unit. Thirty-five percent of the basal area of the current tree density of 439 live trees per acre (Table 6 and Appendix II) will be removed. Approximately 138 western hemlock, 62 Douglas fir, and four western red cedar per acre will be harvested, retaining a tree density of roughly 235 live trees per acre. This will lower the relative density to 42, which should provide optimal growing conditions for the small trees, while maintaining the site as fully forested. This spacing will allow the trees to develop large crowns that in turn promotes rapid radial increment and large root structures, creating good future wind firmness. Although the height to diameter ratio will be lowered from 81 to 75 as a result of the thinning, the risk of windthrow is still significant. The position high on the slope exposes this unit to greater wind velocities than units at lower slopes. Consequently, no gaps will be created on this unit because of the risk of windthrow.

6.2.8 Ecological Thinning Unit 8 (E8)

Ecological Thinning Unit 8 is located in the western end of the Project Area, adjacent to E1, south of the 700 Road. It is generally flat and is located on a southwesterly aspect, with an elevation of approximately 1,800 asl. This is a small (15 acres) experimental unit in which the treatment will consist of a traditional "thin from below" prescription (i.e., the thinning pool will consist of the only smallest trees in the unit, leaving all larger diameter trees).

Because of the relatively low height to diameter ratio of 74, 35 percent of the basal area will be removed to provide optimal growing space for the remaining trees while minimizing risk of windthrow. To remove 35 percent of the basal area, all of the western hemlock and Douglas-fir ≤12 inches dbh, and 43 percent of the 13 inch dbh western hemlock will be cut. This will reduce the RD from 91 to 52, and the live tree density from 369 to 142 trees per acre. The relative density of 52 results from retaining only the largest trees on the unit. This relative density should achieve the goal of maintaining or increasing residual tree growth. Because no dominant or co-dominant canopy will be removed, however, we predict that this prescription will not significantly affect the light regime on the forest floor, and therefore will not achieve our objectives of increasing plant species diversity, facilitating understory development, or increasing vertical forest structural complexity. One ¼ acre gap and untreated skip area will be created in this unit, to provide horizontal structural complexity and within-patch heterogeneity.

This unit, along with Unit E3, will provide data from an array of thinning treatments ranging from this traditional "thin from below" to removing some co-dominant canopy (as recommended by Lindenmayer and Franklin 2002). Results will be monitored for use in future management decisions.

6.2.9 Restoration Thinning Unit (RT)

The Restoration Thinning Unit (14 acres) is located on a steep slope north of E7 and east of L2, on the north side of the main ridge. During the 2001 forest inventory 373 live trees per acre ≥6 inches dbh were measured, although the actual density is much higher because most of the trees are <6 inches dbh. Only western hemlock ≤11 inches dbh, Douglas-fir ≤ 14 inches dbh, and western red cedar ≤ 14 inches dbh were present. The primary goals for this small unit are to increase residual tree growth by reducing inter-tree competition and to enhance species diversity.

No equipment will be allowed in this unit. We will use hand thinning techniques to an obtain estimated leave tree density of 185 trees per acre, removing 32% of the basal area and reducing the relative density from 54 to 34. This treatment should provide optimal growing space for the residual trees. Only the most prevalent species (western hemlock and Douglas-fir) will be thinned, with all western red cedar retained. This will not only enhance species diversity indices on the site, but will also provide structural complexity by retaining some smaller diameter trees. There will be 56 larger diameter Douglas-fir (11-14 inches dbh) per acre retained. We expect these trees to become the dominant cohort in this forest patch. The wider spacing of these larger trees will allow them to grow rapidly in both diameter and height, develop large limbs, and deep crown structure, all important wildlife habitat variables. This spacing should also allow the trees to develop large root systems, providing stability against windthrow. Retaining the larger diameter trees and all western red cedar will result in variable spacing between trees, enhancing structural complexity.

To remove 32 percent of the basal area, all western hemlock ≤ 7 inches dbh and Douglas-fir ≤ 8 inches dbh, plus a portion of the nine and ten-inch dbh Douglas-fir will be thinned. All thinned trees will be retained in this unit as DW. Although this will increase the fire risk in the short term, it will also increase the nutrient availability and enhance soil formation processes on this site. To reduce the fire risk, all thinned trees will be cut such that they lay no higher than 20 inches from the ground surface. No snags will be created at this time because of the relatively few larger diameter trees present. No gaps will be created on this site because of the risk of windthrow.

6.3 Future Silvicultural Treatments

The Project Area will be monitored before and after ecological thinning and will be managed adaptively (see section 9). Management decisions, including the ecological value of additional silvicultural treatments, will be based on these monitoring data, along with the relative need for restoration at other sites, labor, costs, and asset management considerations. We will evaluate E1, E2, and E8 after ten years to determine if additional thinning would be beneficial. We expect a slower overstory response from E4, E5, E6, and E7, and will evaluate these units after 15 years to determine whether further thinning would be ecologically beneficial. We do not anticipate reentering E3 because of the large number of snags created and our interest in understanding the long-term effects of removing some dominant tree canopy through snag creation. We expect that the RT unit would benefit from ecological thinning in approximately 20-30 years.

A management decision about whether it would be beneficial to plant a diversity of understory species, especially in the canopy gaps, will be based on the understory monitoring data. If the expected diversity of native understory species have not occurred within three years after thinning, we will supplement the species diversity by selective planting. Planting treatments will be developed at that time. Because lack of understory response could be due to many factors (e.g., depauperate seed bank, poor dispersal from adjacent forests, inadequate canopy openings), the planting treatments will include varied techniques and follow-up monitoring. We may also experiment with planting non-conventional organisms such as canopy lichens and heart rot fungus.

7.0 HARVEST/ ENGINEERING SYSTEM

We expect to utilize a combination of harvest engineering systems throughout the Project Area, including ground-based equipment, skyline systems, and helicopter yarding. Only existing roads will be used, with no road reconstruction or new road construction required. All felling and yarding of logs will be implemented with the minimum ground disturbance possible. Other restrictions include:

- no ground-based machinery will be allowed within 30 feet of a stream channel,
- no logs will be dragged through a stream channel,
- if some trees must be moved over a stream channel, there must be no ground or canopy disturbance,
- skyline yarding must not damage live crowns of retained trees,
- live tree tops must not be broken, and
- there must be minimal bark and root damage to the retained trees.

A full explanation of the harvest systems analyzed and recommendations put forth by the silvicultural engineer is included in Appendix VI. We expect to use ground-based systems on the slopes less than 35 percent, skyline systems on steeper slopes with access to existing maintained roads, and helicopter yarding on the ridge top, where there is no road access. Recommendations from the silvicultural engineer by unit are: E1 - a combination of ground-based and skyline systems; E2 - ground-based; E3 and E4 - a combination of skyline and helicopter logging; E5 and E6 - a combination of ground-based, skyline, and helicopter; and E7 - ground-based. Note: Unit E8 was created out of a section of E1 subsequent to the silvicultural engineering report, so recommendations for E8 will be the same as for E1. Other potential site-specific combinations proposed by contractors will be considered by the project planning team if they can accomplish the goals of no road construction and minimal ground disturbance, while adhering to all other restrictions. The harvest engineering report (Appendix VI) will provide insight that staff will use to judge the service contract proposals.

Ground-based equipment will likely include a tracked, cut-to-length processor and full suspension forwarder to minimize soil disturbance and damage to the remaining trees. Cut-to-length processors cut the trees, strip the branches on site, and move forward on paths cushioned by the branches, thereby minimizing soil disturbance and compaction. The processor piles logs that are then picked up by and loaded onto the forwarder that carries, but does not drag, the logs to a nearby road or landing. Forwarders are agile machines that minimize damage to soil and remaining trees because logs are not dragged along the ground or against trees. All yarding corridors and skid trails will be flagged by the contractor and approved by watershed staff before installation and use. Logs will be moved to established roads to provide log trucks easy access and minimal turn-around needs.

8.0 RISKS, BENEFITS, AND COSTS

8.1 Risks

The competitive exclusion stage of forest development (the stage of the forest in the Project Area) is structurally simple, with little or no understory development, little structural complexity, and little plant diversity (Oliver et al. 1985). This stage provides habitat for a limited number of wildlife species (Erickson 1997, Manuwal 1997, West 1997). Maturation is a much more biologically diverse stage, supporting a wider array of wildlife species, including many that are listed in the CRW-HCP (Aubry et al. 1997). If the Project Area is not ecologically thinned, it will likely remain in the competitive exclusion stage for many decades. Because of the high density of trees there is a risk some parts of the Project Area will approach stagnation, where little or no growth occurs for many decades and the forest is dominated by small dense trees with sparse understory (Oliver and Larson 1996, Spies 1997).

The 62-67 year-old trees in the Project Area currently have sufficient crown depth to respond fairly rapidly to the increased light availability that will result from the thinning. Continued crowding, however, could result in a loss of crown, decreased root development, and increased height:diameter ratios, resulting in “spindly” trees that are tall, but have small diameter and little root strength (Wonn and O’Hara 2001). If forests are left in this condition, trees can become so unstable that they often remain standing only by mutually supporting each other (Groome 1988). This increases the risk of large areas of windthrow during storm events and decreases the ability of individual trees to respond to increased light when it does become available (Oliver and Larson 1996, Wonn and O’Hara 2001).

There is mimimal risk to existing cultural resources as a result of the thinning operation. If any prehistoric cultural resources are discovered during the thinning treatment, the operation will be stopped and additional cultural surveys conducted. If necessary, the area around the resource will be buffered to ensure protection and a contract modification will be done. The thinning operation will minimize ground disturbance, using slash from harvested trees to protect the ground surface, which should help protect subsurface relicts, if they exist.

Uncertainty does exist about the exact response of trees, shrubs, herbs, and wildlife to the ecological thinning treatments (see section 9.1). These uncertainties pose little risk to the forest, however.

8.2 Benefits

The primary benefit of ecological thinning relative to forest successional development is that it significantly shortens the time to the maturation stage (likely by 50 years or possibly much more), consequently providing LSF habitat to late-successional dependent species much sooner than would otherwise develop. Carey et al. (1999b) found that actively managing forests for biodiversity resulted in a much more rapid development of LSF conditions compared with no management (80 years versus 180 years to reach LSF conditions). In the short term, even standard thinning from below treatments have been shown to benefit many wildlife species. In closed-canopy forest stands that had never been thinned, there was no bat activity and very limited use by small mammals, birds, and amphibians (Aubry 1997, Aubry 2000, Erickson 1997, Manuwal and Pearson 1997, West 1997). Thinned forest stands showed much higher wildlife use than unthinned stands, both in these studies and in others (Hagar et al. 1996, Haveri and Carey 2000, Humes et al. 1999, Suzuki and Hayes 2003, Wilson and Carey 2000). The limited data available for variable density thinning indicates it provides even better current wildlife habitat than standard thinning from below (Carey and Johnson 1995). In addition, habitat elements such as deciduous trees and shrubs, snags, and DW are critical to numerous species and will be retained and enhanced during ecological thinning. Creating snags and supplementing existing DW will provide critical habitat elements in the near term that are used by approximately 110 wildlife species potentially occurring in the CRMW (Johnson and O'Neill 2001). Snags are generally deficient over much of the CRMW, and we anticipate the created snags will be used by a wide range of species as soon as they reach appropriate decay stages.

There is a large amount of data that indicates wider spacing of trees results in less instability (i.e., better root strength) and greater opportunity for crown differentiation (Oliver and Larson 1996). This will reduce the risk of windthrow while facilitating forest development. In addition, a benefit may accrue to future cultural resources for native Americans, in that late-successional forests could support plants of cultural importance or create environments that might become spiritually important.

8.3 Costs

We expect that the 700 Road Forest Habitat Restoration Project will be revenue neutral, based on costs already incurred (including staff time, cultural resource plan development and surveys, data collection, and engineering consultants), future anticipated costs (including monitoring, snag creation, harvest costs, and the post-thinning forest inventory), and projected revenues (based on the current market value of trees removed). Snag creation costs vary, depending on the technique (see Appendix IV), so an average of $30 per snag was used for this estimate.

9.0 MONITORING

9.1 Uncertainties

While the growth response of trees to standard thinning from below is well documented, the growth response of trees to ecological thinning may differ. In addition, the response of understory plants is less understood, particularly when using thinning solely to enhance the ecological and habitat value of a site. Because of these uncertainties, we will monitor the results of the different treatments and use the information in planning future restoration projects. Other uncertainties include the ideal number of snags to create for current habitat use, and the best methods for snag creation. In deciding the number of snags to create, we used expert opinion and best professional judgement, balanced with achieving the other objectives and the cost of snag creation. We will create a variable number of snags across the Project Area using a variety of techniques, and monitor a sample of them for longevity, decay rate, and habitat use. Finally, the number and size of gaps and untreated skip areas that should be created to create mosaics of habitat diversity and structural complexity is not known. To address this uncertainty, we will monitor plant and selected animal responses in the different sized gaps.

9.2 Compliance Monitoring

A trained Contract Administrator will be on site daily during the ecological thinning operation to ensure that contract specifications and the marking and harvest guide (Appendix V) are followed, as well as to serve as the contact person in case any large snags or DW are found. Trees to be thinned will not be marked prior to the thinning, although a sample area may be marked if requested by the operator. Compliance monitoring will also include a post-thinning forest inventory within one year of the completion of the ecological thinning, both to validate the projected tree densities and basal area of the thinning units, and to serve as the baseline for future monitoring in the thinned units. Leave tree densities that are within ten percent of our predicted values will be considered within acceptable limits for contract compliance. If results are outside of these limits we will evaluate corrective actions.

9.3 Effectiveness Monitoring

It is essential that responses to the restoration interventions and thinning techniques are monitored because of the experimental nature of the ecological thinning treatment and the range of treatments employed. Monitoring will allow managers and scientists to adaptively apply knowledge gained on the Project Area to portions of the remaining forest to accelerate this type of forest toward late-successional habitat. Success in achieving the five ecological objectives (listed in Table 4) will be evaluated using a combination of monitoring techniques and measurements (Table 9). Our hypotheses about the effects of the ecological thinning on individual tree, canopy, understory and dead wood processes are listed in Figure 5.

Table 9. Monitoring techniques used to evaluate the success in achieving the five management objectives in the 700 Road Forest Habitat Restoration Project Area.

Objective	Monitoring Technique, Measurement
Maintain or Increase Growth Rate of Trees	Compare increment cores, dbh, height, percent live crown, and height to lowest live limb on representative trees in thinned and control plots
Increase Species Diversity; Facilitate Understory Development	Compare understory (shrub, fern and herbaceous vegetation) species presence and percent cover in thinned and control plots. Compare tree seedling regeneration in thinned and control plots.
Increase Structural complexity	Compare height, height to lowest live limb, percent live crown, and presence of epicormic branching in thinned and control plots. Compare relative bat use in thinned and leave units.
Increase Snag Density; Facilitate Recruitment of Large-Diameter Snags and DW	Compare snag and DW density, diameter, height or length, and decay class in thinned and control plots. Compare snag creation techniques for decay rate, longevity, and habitat use. Compare relative bat use in thinned and leave units.
Protect Special Habitats/Water Quality	During ecological thinning and planting operations, ensure no equipment enters within 30 feet of the stream channels (contract compliance).

Our specific effectiveness monitoring key questions include:

1. How does the growth rate and other associated variables of trees retained in ecological thinning units compare to those in untreated leave units?
2. How does understory plant and tree seedling regeneration compare in thinned and leave units?

3. How does understory plant and tree seedling regeneration compare in gaps versus thinned areas and leave areas?
4. How does snag and DW density compare in ecological thinning and leave units?
5. How do the leave tree variables, understory and tree seedling regeneration, and snag and DW compare among the different restoration treatments?
6. How do the different snag techniques compare, in terms of longevity, decay rate, and habitat use?

We will install nine monitoring plots in ecological thinning units (two in E1, one in E2, two each in E3 and E8, one in E5 and one in E6) and one in each leave unit, for a total of 12 plots. Initial baseline measurements will be taken during spring and summer of 2004. Monitoring plot layout will utilize the design for Permanent Sample Plots in CRMW, and will be placed on a random systematic grid developed for the entire CRMW (Munro et al. 2003). Trees and snags will be measured in a circular 1/5-ac slope-corrected plot (species, dbh, stratum, crown class, percent live crown, presence/type of damage, presence of mistletoe, presence of epicormic branching, decay class). Height will be estimated on all snags, and measured on a subsample of at least three trees per stratum, with a minimum of 12 trees measured for height. Three trees per stratum will also be cored for growth rate. At plot center, digital photographs will be taken in each of the four cardinal directions, and slope and aspect recorded. Transects (25 meters = 82 feet) will be established in the four cardinal directions from plot center, and used to measure DW. The first 52.7 feet from plot center (the amount enclosed by the tree plot) on each transect will be used to measure short shrubs (all shrubs except vine maple), using the line-intercept method. This same segment of the transect will be used as the center of a 2-meter (6.6 feet) belt transect, in which percent cover of tall shrubs (vine maple) will be estimated and number of seedlings and saplings will be counted by species by class (6 inches-4.5 feet in height, >4.5 feet tall 0-3 inches dbh, >4.5 feet tall 3-5 inches dbh). Percent cover of herbs (by species), mineral soil, rock, and duff will be estimated by cover class in one-meter square plots located at 10, 20, and 30 feet from plot center along the four transects (offset by four feet from the transect to avoid trampling). Canopy cover will be estimated using a densiometer at 20 feet from plot center along each of the four transects.

Rapid responses by overstory trees to the restoration treatments are not expected, so these trees will be monitored on the 12 plots ten years after the ecological thinning, with subsequent monitoring frequency to be decided at that time. Understory vegetation and tree regeneration will be monitored more frequently, at one and five years post-thinning, then coincident with the tree monitoring. If funding is available, we will also monitor understory vegetation and tree regeneration at three years post-thinning. This level of monitoring should allow evaluation of the successional trajectory in the thinned units and whether the objectives delineated in this management plan are being achieved.

We will also monitor two to three gaps of each size for understory response and seedling regeneration (the number of gaps monitored will be contingent on cost). Four transects will be placed in the four cardinal directions, extending from the center of the gap to the forest edge. Cover by shrub species will be measured using the line-intercept method. Percent cover of herbs (by species), small seedlings <6" in height, mineral soil, rock, and duff will be estimated by cover class in one-meter square plots in three plots per transect. The herb plots will be located 15 feet from the gap center, 15 feet from the forest edge, and equidistant between these two, offset from the transect by four feet. Saplings will be placed into one of three classes (6 inches-4.5 feet in height, >4.5 feet tall 0-3 inches dbh, >4.5 feet tall 3-5 inches dbh), and will counted by species in a two meter wide belt transect centered along each transect. Gaps will be monitored at one, five, and ten years post-gap creation, with the continuing monitoring schedule to be determined at that time. In addition, at five years we will visually inspect the forest edges surrounding the gap and, based on the understory response, make a decision about whether to extend the transects into the surrounding forest. As with the other monitoring plots, if funding is available, the gaps will also be monitored at three years post-creation.

A sample of snags from each creation method will be permanently marked and monitored every five years for longevity, decay rate, and wildlife use. We will determine the exact number of created snags to monitor and the specific snag monitoring protocol once the final selection of trees (species and dbh) for snag creation is complete. This will occur during the thinning treatment, anticipated to start in 2005.

Watershed managers and scientists anticipate that implementation of the management actions specified in this plan will accelerate development of a naturally functioning late-successional forest, which will be documented by comparing monitoring results from the thinned versus untreated leave units. Monitoring may or may not indicate that future management actions (e.g., further ecological thinning, restoration planting, or creation of snags or DW) are warranted to achieve the management objectives. The benefit of future actions will be weighed against the ecological cost of repeated entry.

9.4 Validation Monitoring

Certain wildlife species can serve as indicators of forest composition, structure and function. Their presence or level of activity in the Project Area may validate that the objective of accelerating LSF characteristics with respect to wildlife use is being achieved. Forest-dwelling bats use large-diameter snags and the thick or peeling bark of older trees for maternity colonies, as well as for day and night roosts. They forage in more open areas, such as canopy gaps found in old growth. Bat activity was found to be significantly higher (2.5 to 9.8 times as much activity) in old-growth forest (>200 years) than in mature and young unmanaged forests (35-195 years) (Thomas and West 1991). No bats were detected in managed 30-40 year old closed-canopy forests in a 2-year study (Erickson 1997). As such, bats may be useful indicator species to evaluate the structural complexity associated with late-successional forests.

This Project Area will be used as an experimental site to test the assumption that bats can be used as an indicator of late-successional conditions on a moderate growing site. Our key question is: How does relative bat use compare in thinned areas, in gaps, and in untreated leave units? We expect that bat foraging use will increase in thinned area and gaps within one year of the ecological thinning. Because maternity colonies and roosting sites require structures that will take considerable time to develop, we do not expect to find these colonies on the Project Area for many years. Baseline bat presence and relative use of E1 and E2 was conducted in June-August 2002 and 2003, by recording the ultrasonic calls using an ultrasonic detecting and recording devise (Titley Electronics). Limited bat use was found within the Project Area, though extensive use was documented over the adjacent Rex River. Bat calls will be analyzed to identify species or species groups. Monitoring bat use in the thinned areas in E1 and E2, in a sample of each size gap in E1 and E2, and in L1 and L3 will occur at one, five and ten years after the completion of the ecological thinning. This will enable us to determine if the density of leave trees provide habitat suitable for bat foraging, and whether bats will use the various sizes of gaps. Results will be included in the periodic monitoring reports.

10.0 IMPLEMENTATION AND DOCUMENTATION

10.1 Seattle City Council Ordinance

Selling surplus logs in excess of 250 MBF per year from the CRMW requires the approval of the Seattle City Council through issuance of an ordinance. An ordinance will be submitted to the City Council in the summer of 2004. Upon its approval, a copy of the ordinance will be included in Appendix VII of this plan.

10.2 Contracts

Following the approval of the ordinance by the Seattle City Council, the City will award a contract for the ecological thinning work to a qualified contractor. The contract will specify a minimum bid, based on an appraisal of the value of the trees to be removed from the Ecological Thinning Units, as designated in this Plan. The invitation to bid will request proposals, including engineering designs, regarding how the Project Area will be thinned. The recommendations from the silvicultural engineer will be made available to prospective bidders, upon request. The contract will be sold to the highest bidder with the best project design that meets specific qualifications. A copy of the contract will be included in Appendix VII of this plan. This contract is anticipated to be completed in the fall of 2004. The thinning is expected to begin in 2005 and may take up to three years, with an estimated 4.4 million board feet of trees removed from the Project Area. Although the project is expected to be revenue neutral, if some positive revenue is generated from the thinning, it will be used to help fund other HCP-related activities, including but not limited to cultural resources surveys, monitoring, and third party certification.

The RT unit will be thinned using a separate contract, and the work may be included in other appropriate restoration thinning contracts.

10.3 Project Completion

A short report will be prepared, if needed, to describe any instances where field treatments were modified during implementation of the ecological and restoration thinning. The reasons for such modification will be described. Details such as skid trail locations will be recorded. The data from the post-treatment forest inventory will be included in this project completion report.

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Appendix I
Glossary of Terms

Adaptive management	As applied in the CRW-HCP, the process of adaptive management is defined with three basic elements: (i) an initial operational decision or project design made in the face of uncertainty about the impacts of the action; (ii) monitoring and research to determine impacts of actions; and (iii) changes to operations or project design in response to new information.
Aspect	The direction a slope faces with respect to the cardinal compass points. Fore example, a hillside facing east has an eastern aspect.
Basal area	The cross sectional area of a tree at breast height, usually summed by species over a given area.
Biodiversity	Biological diversity; the combination and interactions of genetic diversity, species composition, and ecological diversity (including factors such as age, form, structure, and location) in a given place at a given time.
Biological legacies	As defined in the CRW-HCP: Features of a previous forest that are retained at timber harvest or left after natural disturbances, including old-growth or other large diameter snags, stumps, live trees, logs, soil communities, hardwood trees, and shrubs. Also referred to as legacies.
Board feet	A measurement of lumber volume. A board foot is equal to 144 cubic inches of wood.
Canopy	The cover of branches and foliage formed collectively by the crowns of trees or other growth. Also used to describe layers of vegetation or foliage below the top layer of foliage in a forest, as when referring to the multi-layered canopies or multi-storied conditions typical of ecological old-growth forests.
Canopy closure	The degree to which the boles, branches, and foliage (canopy) block penetration of sunlight to the forest floor or obscures the sky; determined from measurements of density (percent closure) taken directly under the canopy.

Cedar River Watershed	An administrative unit of land owned by the City of Seattle for the purposes of providing a municipal water supply. The 91,346-acre municipal watershed within the upper part of the Cedar River Basin lies upstream from the City's water intake at Landsburg Diversion Dam. It is composed of eight major subbasins and 27 subbasins, 26 of which drain into the Cedar River. It supplies about 2/3 of the drinking water to Seattle Public Utilities' water service area.
Co-dominant trees	Trees or shrubs with crowns receiving full light from above, but comparatively little from the sides. Crowns usually form the general level of the canopy.
Competitive exclusion	A phase in which the canopy closes and competition among trees becomes intense in a developing stand. Also sometimes called stem exclusion.
Compliance monitoring	Monitoring performed to determine whether contracts are implemented as written.
Conifer	A tree belonging to the taxonomic order Gymnospermae, and comprising a wide range of trees that are mostly evergreen. Conifers bear cones and have needle-shaped or scalelike leaves.
Decay class	One of five recognizable stages of wood decay as a fallen tree decomposes and is reincorporated into the soil. Factors that categorize stages of decay include bark and twig presence or absence, log texture and shape, wood color, position relative to the ground, and presence or absence of invading roots (Maser and Trappe 1984).
Deciduous trees	Flowering trees, belonging to the taxonomic order Angiospermae, with relatively broad, flat leaves, as compared to conifers or needle-leaved trees.
Disturbance	Significant change in forest structure or composition through natural events (such as fire, flood, wind, earthquake, or disease) or human-caused events (forest management).
Dominant Tree	Trees with crowns receiving full light from above and partly from the side; usually larger than the average trees in the stand, with crowns that extend above the general level of the canopy and that are well developed but possibly somewhat crowded on the sides. A dominant tree is one which generally stands head and shoulders above all other trees in its vicinity.

Ecological thinning	As defined in the CRW-HCP: The experimental silvicultural practice of cutting, damaging, or otherwise killing some trees from some areas of older, overstocked, second-growth forest (typically over 30 years old). The intent of ecological thinning is to encourage development of the habitat structure and heterogeneity typical of late-successional and old-growth stands, characterized by a high level of vertical and horizontal stand structure, and to improve habitat quality for wildlife. It is expected that techniques will include variable-density thinning to create openings, develop a variety of tree diameter classes, develop understory vegetation, and recruit desired species; and creating snags and logs by uprooting trees, felling trees, topping trees, injecting trees with decay-producing fungus, and other methods. Ecological thinning does not have any commercial objectives. However, in those cases in which an excess of woody material is generated by felling trees, trees may be removed from the thinning site and may be sold or used in restoration projects on other sites.
Effectiveness monitoring	Monitoring to determine whether implemented restoration activities result in anticipated habitat conditions or effects on species.
Even-aged forest	A forest with minimal differences in age, generally less than 10 years, between trees.
Forest stand	A group of trees that possess sufficient uniformity in composition, structure, age, spatial arrangement, or condition to distinguish them from adjacent groups of trees. Also referred to as stand.
Forest succession	The sequential change in composition, abundance, and patterns of species that occurs as a forest matures after an event in which most of the trees are removed. The sequence of biological communities in a succession is called a sere, and the communities are called seral stages.
Habitat	The sum total of environmental conditions of a specific place occupied by plant or animal species or a population of such species. A species may require or use more than one type of habitat to complete its life cycle.

Habitat Conservation Plan (HCP)	As defined under Section 10 of the federal Endangered Species Act, a plan required for issuance of an incidental take permit for a listed species. Called "conservation plans" under the Act, HCPs can address multiple species, both listed and unlisted, and can be long term. HCPs provide for the conservation of the species addressed, and provide certainty for permit applicants through an implementation agreement between the Secretary of the Interior or Secretary of Commerce and a non-federal entity.
Interior forest conditions	Forest conditions that are largely not affected by edge effects, which occur where large openings abut the forest. Edge effects that are know to occur in some areas include penetration of light and wind, temperature changes, and increased predator activity. Interior forest condition are achieved at sufficient distance from an edge so that edge effects are minimal.
Landsburg Diversion Dam	The low dam at the site of the diversion for uptake of drinking water operated by Seattle Public Utilities, located at River Mile 21.8 of the Cedar River. As a run-of-the-river dam, it does not create a significant impoundment of water upstream. Also referred to as Landsburg Dam.
Late-successional forest	Forest in the later stages of forest succession; the sequential change in composition, abundance, and patterns of species that occurs as a forest matures. As used in the CRW-HCP, refers to conifer forests 120-189 years of age. Characterized by increasing biodiversity and forest structure, such as a number of canopy layers, large amounts of coarse woody debris, light gaps (canopy openings), and developed understory vegetation.
Legacies	See biological legacies.
Listed wildlife species, federal	Under the federal Endangered Species Act, species, or sub-unit of a species, formally listed in the Federal Register as endangered or threatened by the Secretary of the Interior or the Secretary of Commerce. A listing refers to the species or sub-unit by scientific and common name and specifies over what portion of its range it is endangered or threatened.
Macrolichen	A lichen is a symbiotic association between a fungus and a photosynthetic partner (green algae, cyanobacteria or both). Macrolichens include foliose (leaflike) and fruticose (shrublike) lichens.

Management prescriptions	A set of procedures designed to accomplish a specific management objective.
Monitoring	The process of collecting information to evaluate if objectives and anticipated results of a management plan are being realized or if implementation is proceeding as planned. This may include assessing the effects upon a species' habitat.
Native species	Any wildlife species naturally occurring in a specific area of Washington for purposes of breeding, resting, or foraging, excluding introduced species not found historically in this state; defined by WAC 232-12-297.
Old-growth conditions	Conditions in older conifer forest stands, with vertical and horizontal structural attributes sufficient to maintain some or all of the ecological functions of natural "ecological old-growth" forest, which is typically at least 200 years old and often much older.
Old-growth forest	As used in the CRW-HCP, native unharvested conifer forest in the Cedar River Municipal Watershed that is at least 190 years of age, but which does not necessarily exhibit "ecological old-growth" conditions.
Overstory	That portion of the trees, in a forest of more than one story, forming the upper or uppermost canopy layer.
Regeneration	The seedlings and saplings existing in a stand; the act of establishing young trees naturally or artificially.
Restoration planting	Planting of native trees, shrubs, and other plants to encourage development of habitat structure and heterogeneity, to improve habitat conditions for fish and wildlife, and to accelerate development of old-growth conditions or riparian forest function in previously harvested second growth.
Second-growth	Forest stands in the process of regrowth after an earlier cutting or disturbance.
Seral stage	A particular stage (ecological community) in a sere, or pattern of succession. As used in the CRW-HCP, applies to forest succession
Silviculture	The theory and practice of controlling the establishment, composition, growth, and quality of forest stands in order to achieve management objectives. Includes such actions as thinning, planting, fertilizing, and pruning.

Site index	The total height to which dominant trees of a given species will grow on a given site at some index age, often 50 or 100 years
Slope	A measure of the steepness of terrain, equal to the tangent of the angle of the average slope surface with the horizontal, expressed in percent. A 100 percent slope has an angle with the horizontal of 45 degrees, a 70% slope has an angle of 35 degrees, and a 30 percent slope has an angle of 17 degrees.
Snag	A standing dead tree.
Species	A unit of the biological classification system (taxonomic system) below the level of genus; a group of individual plants or animals (including subspecies and populations) that have common attributes and are capable of interbreeding. The federal Endangered Species Act defines species to include subspecies and any “distinct population segment” or “evolutionarily significant unit” of any species.
Stagnant Stand	Forest stands whose growth and development have all but ceased due to poor site and/or excessive density of trees (often termed stocking).
Stand	See forest stand.
Structure	The arrangement of the parts of an ecosystem, both vertically and horizontally.
Take	To harass, harm, pursue, hunt, wound, kill, trap, capture, or collect a federally listed threatened or endangered species, or to attempt to do so (ESA, Section 3[10]). Take is prohibited under federal law, except where authorized. Take may include disturbance of the listed species, nest, or habitat when disturbance is extensive enough to disrupt normal behavioral patterns for the species, although the affected individuals may not actually die.
Threatened species, federal	A designation as defined in the federal Endangered Species Act for a species that is likely to become endangered throughout all or a significant portion of its range within the foreseeable future.
Type F waters	Perennial fish-bearing streams, as defined in WAC 222-16-030.
Type S waters	Shorelines of the state, as under chapter 90.58 RCW, in WAS 222-16-030.

Type 1-3 waters	In the context of the HCP, fish bearing waters. Definition based on WAC 222-16-031.
Understory	All forest vegetation growing under an overstory.
Validation Monitoring	Monitoring to determine cause and effect relationships, such as that between habitat and species.
Washington Administrative Code (WAC)	All current, permanent rules of each state agency, adopted pursuant to chapter 34.05 RCW.
Watershed	A basin contributing water, organic matter, dissolved nutrients, and sediments to a stream, lake, or ocean. As applied in the CRW-HCP, used to refer to the Cedar River Municipal Watershed above the Landsburg Diversion Dam and water intake, some of which does not drain into the Cedar River above the Landsburg water intake.
Wetland	Land where the water table is usually at or near the surface or the land is covered by shallow water and has one or more of the following attributes: the land supports, at least periodically, predominantly hydrophytic plants (plants adapted to water or waterlogged soil); substrate is predominantly undrained hydric soils; and/or the substrate is nonsoil and is saturated with water or covered by shallow water at some time during the growing season each year.

Appendix II: Ecological Thinning Unit E1 - Before Thin

700 Road Forest Habitat Restoration Project

Tree data by species

acres: 80

	Western Hemlock			Douglas Fir			Western Redcedar			Silver Fir			Noble Fir			Red Alder			Cottonwood			Snags			Total Live			Total			Summary		
Size (dbh)	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF
6	0.0	0.0	0	0.0	0.0	0	14.4	2.9	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	14.4	2.9	0	14.4	2.9	0			
7	4.0	1.1	80	0.0	0.0	0	4.4	1.2	132	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	8.4	2.3	212	8.4	2.3	212			
8	20.0	6.7	496	0.0	0.0	0	4.2	1.3	0	3.0	1.1	90	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	27.2	9.1	586	27.2	9.1	586	106.0	41.0	3,106
9	15.5	6.5	592	0.0	0.0	0	6.2	2.6	78	0.0	0.0	0	2.4	1.1	95	2.5	1.1	102	0.0	0.0	0	0.0	0.0	0	26.6	11.3	867	26.6	11.3	867			
10	18.8	9.7	896	3.8	2.1	225	4.7	2.5	232	0.0	0.0	0	0.0	0.0	0	2.2	1.2	88	0.0	0.0	0	0.0	0.0	0	29.4	15.5	1,441	29.4	15.5	1,441			
11	15.3	9.7	1,062	1.7	1.1	100	9.5	5.9	525	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	26.4	16.7	1,687	26.4	16.7	1,687			
12	7.1	5.4	560	0.0	0.0	0	4.6	3.5	321	1.3	1.0	131	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	12.9	9.9	1,012	12.9	9.9	1,012			
13	19.6	17.5	2,189	1.4	1.2	55	3.9	3.6	233	1.2	1.1	148	0.0	0.0	0	1.3	1.2	115	0.0	0.0	0	0.0	0.0	0	27.3	24.5	2,740	27.3	24.5	2,740	108.3	97.9	10,725
14	12.0	12.6	1,550	3.2	3.4	366	6.1	6.4	385	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	21.3	22.4	2,301	21.3	22.4	2,301			
15	9.0	10.8	1,559	0.9	1.2	19	4.0	4.9	430	5.3	6.4	924	0.0	0.0	0	1.1	1.3	53	0.0	0.0	0	0.0	0.0	0	20.4	24.5	2,985	20.4	24.5	2,985			
16	11.7	16.2	2,392	2.4	3.3	498	6.4	8.9	793	0.8	1.1	184	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	21.2	29.4	3,867	21.2	29.4	3,867			
17	9.8	14.9	2,206	3.6	5.7	847	3.3	5.1	438	0.0	0.0	0	0.0	0.0	0	0.7	1.1	141	0.0	0.0	0	0.0	0.0	0	17.4	26.8	3,632	17.4	26.8	3,632			
18	7.4	13.2	1,760	0.6	1.1	191	2.2	3.8	393	1.8	3.2	434	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.6	1.1	125	12.1	21.3	2,778	12.7	22.3	2,903	74.5	125.1	17,202
19	10.0	19.1	2,950	2.9	5.6	882	1.3	2.5	301	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	14.2	27.2	4,133	14.2	27.2	4,133			
20	4.0	8.7	1,311	1.0	2.2	378	3.5	7.4	843	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.5	1.1	135	8.5	18.3	2,532	9.0	19.4	2,667			
21	5.5	13.0	1,948	2.4	5.6	1,088	2.1	5.0	557	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	10.0	23.7	3,593	10.0	23.7	3,593			
22	2.2	5.7	977	2.1	5.5	1,043	0.5	1.3	81	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.4	1.1	135	0.0	0.0	0	5.2	13.5	2,236	5.2	13.5	2,236			
23	2.0	5.7	1,021	1.6	4.7	777	0.0	0.0	0	0.4	1.1	242	0.0	0.0	0	0.0	0.0	0	0.4	1.1	164	0.0	0.0	0	4.4	12.6	2,204	4.4	12.6	2,204	24.6	66.2	10,674
24	2.8	8.6	1,360	0.7	2.2	343	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	3.5	10.8	1,703	3.5	10.8	1,703			
25	0.0	0.0	0	1.3	4.5	773	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.3	1.1	165	0.0	0.0	0	1.6	5.6	938	1.6	5.6	938			
26	0.3	1.1	166	1.2	4.5	928	0.4	1.4	137	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	1.9	7.0	1,231	1.9	7.0	1,231			
27	0.3	1.2	225	1.9	7.7	1,667	0.4	1.5	182	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	2.6	10.3	2,074	2.6	10.3	2,074			
28	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	5.9	24.1	4,623
29	0.2	1.1	70	0.2	1.1	246	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.5	2.1	316	0.5	2.1	316			
30	0.0	0.0	0	1.0	4.7	1,002	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	1.0	4.7	1,002	1.0	4.7	1,002			
31	0.0	0.0	0	0.0	0.0	0	0.3	1.5	177	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.3	1.5	177	0.3	1.5	177			
32	0.0	0.0	0	0.2	1.1	246	0.4	2.0	133	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.6	3.1	379	0.6	3.1	379	1.0	5.8	765
33	0.0	0.0	0	0.2	1.2	209	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.2	1.2	209	0.2	1.2	209			
Total	177.3	188.2	25,370	34.2	69.5	11,883	82.6	75.1	6,371	13.9	15.0	2,153	2.4	1.1	95	7.8	5.9	499	1.1	3.3	464	1.1	2.1	260	319.3	358.0	46,835	320.3	360.1	47,095	320.3	360.1	47,095

Pools

Target[1]	160.0	143.1	18,292	20.4	24.7	3,183	56.8	43.6	3,357	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	237.3	211.4	24,832	237.3	211.4	24,832
Non-Target[2]	17.3	45.0	7,078	13.8	44.8	8,700	25.7	31.5	3,014	13.9	15.0	2,153	2.4	1.1	95	7.8	5.9	499	1.1	3.3	464	1.1	2.1	260	82.0	146.6	22,003	83.1	148.7	22,263

TPA = trees/acre

BA = basal area/acre (sq ft)

BF = board feet/acre

[1]Target Pool = pool from which trees CAN be harvested (shaded area)

[2]Non-Target Pool = pool from which trees CANNOT be harvested (non-shaded area)

Snag Pool= pool from which trees CAN be used for snag creation (bold outline)

Data Collected: 11/2001

Ecological Thinning Unit E1 - After 35% BA Thinning Applied to Target Species by DBH

700 Road Forest Habitat Restoration Project — Acres: 80

Tree data by species — %BA Harvested: 35 — created snags/acre target: 4 — 15-19" dbh

	Western Hemlock			Douglas Fir			Western Redcedar			Silver Fir			Noble Fir			Red Alder			Cottonwood			Snags			Total Live			Total			Summary		
Size (dbh)	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF
6	0.0	0.0	0	0.0	0.0	0	5.8	1.2	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	5.8	1.2	0	5.8	1.2	0			75
7	1.6	0.4	32	0.0	0.0	0	4.4	1.2	132	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	6.0	1.6	164	6.0	1.6	164			
8	8.1	2.7	200	0.0	0.0	0	4.2	1.3	0	3.0	1.1	90	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	15.3	5.1	290	15.3	5.1	290	57.7	22.3	1,603
9	6.2	2.6	239	0.0	0.0	0	6.2	2.6	78	0.0	0.0	0	2.4	1.1	95	2.5	1.1	102	0.0	0.0	0	0.0	0.0	0	17.3	7.5	514	17.3	7.5	514			
10	7.6	3.9	362	1.5	0.9	91	1.9	1.0	94	0.0	0.0	0	0.0	0.0	0	2.2	1.2	88	0.0	0.0	0	0.0	0.0	0	13.2	7.0	634	13.2	7.0	634			
11	6.2	3.9	429	0.7	0.4	40	3.8	2.4	212	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	10.6	6.7	681	10.6	6.7	681			
12	2.8	2.2	226	0.0	0.0	0	1.8	1.4	130	1.3	1.0	131	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	6.0	4.6	487	6.0	4.6	487			
13	7.9	7.1	884	0.6	0.5	22	1.6	1.4	94	1.2	1.1	148	0.0	0.0	0	1.3	1.2	115	0.0	0.0	0	0.0	0.0	0	12.5	11.2	1,263	12.5	11.2	1,263	50.6	47.0	5,259
14	4.8	5.1	626	1.3	1.4	148	2.5	2.6	155	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	8.6	9.0	929	8.6	9.0	929			
15	3.6	4.4	629	0.4	0.5	8	1.6	2.0	174	5.3	6.4	924	0.0	0.0	0	1.1	1.3	53	0.0	0.0	0	0.8	0.9	111	12.0	14.5	1,788	12.8	15.4	1,899			
16	4.7	6.5	966	1.0	1.3	201	2.6	3.6	320	0.8	1.1	184	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	1.1	1.6	204	9.1	12.5	1,671	10.2	14.1	1,876			
17	3.9	6.0	891	1.5	2.3	342	1.3	2.1	177	0.0	0.0	0	0.0	0.0	0	0.7	1.1	141	0.0	0.0	0	0.9	1.4	194	7.5	11.5	1,551	8.4	12.9	1,744			
18	3.0	5.3	711	0.3	0.5	77	2.2	3.8	393	1.8	3.2	434	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	1.0	1.8	252	7.2	12.8	1,615	8.3	14.6	1,867	43.1	74.8	10,215
19	4.0	7.7	1,191	1.2	2.3	356	1.3	2.5	301	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.7	1.4	213	6.5	12.5	1,848	7.2	13.8	2,061			
20	4.0	8.7	1,311	1.0	2.2	378	3.5	7.4	843	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.5	1.1	135	8.5	18.3	2,532	9.0	19.4	2,667			
21	5.5	13.0	1,948	2.4	5.6	1,088	2.1	5.0	557	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	10.0	23.7	3,593	10.0	23.7	3,593			
22	2.2	5.7	977	2.1	5.5	1,043	0.5	1.3	81	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.4	1.1	135	0.0	0.0	0	5.2	13.5	2,236	5.2	13.5	2,236			
23	2.0	5.7	1,021	1.6	4.7	777	0.0	0.0	0	0.4	1.1	242	0.0	0.0	0	0.0	0.0	0	0.4	1.1	164	0.0	0.0	0	4.4	12.6	2,204	4.4	12.6	2,204	24.6	66.2	10,674
24	2.8	8.6	1,360	0.7	2.2	343	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	3.5	10.8	1,703	3.5	10.8	1,703			
25	0.0	0.0	0	1.3	4.5	773	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.3	1.1	165	0.0	0.0	0	1.6	5.6	938	1.6	5.6	938			
26	0.3	1.1	166	1.2	4.5	928	0.4	1.4	137	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	1.9	7.0	1,231	1.9	7.0	1,231			
27	0.3	1.2	225	1.9	7.7	1,667	0.4	1.5	182	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	2.6	10.3	2,074	2.6	10.3	2,074			
28	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	5.9	24.1	4,623
29	0.2	1.1	70	0.2	1.1	246	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.5	2.1	316	0.5	2.1	316			
30	0.0	0.0	0	1.0	4.7	1,002	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	1.0	4.7	1,002	1.0	4.7	1,002			
31	0.0	0.0	0	0.0	0.0	0	0.3	1.5	177	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.3	1.5	177	0.3	1.5	177			
32	0.0	0.0	0	0.2	1.1	246	0.4	2.0	133	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.6	3.1	379	0.6	3.1	379	1.0	5.8	765
33	0.0	0.0	0	0.2	1.2	209	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.2	1.2	209	0.2	1.2	209			
Total	81.9	102.8	14,464	22.1	54.8	9,985	48.7	49.1	4,369	13.9	15.0	2,153	2.4	1.1	95	7.8	5.9	499	1.1	3.3	464	5.1	8.2	1,109	177.8	231.9	32,029	182.9	240.1	33,139	182.9	240.1	33,214

Trees

	Western Hemlock			Douglas Fir			Western Redcedar			Silver Fir			Noble Fir			Red Alder			Cottonwood			Snags			Total Live			Total		
Removed[1]	95.4	85.3	10,906	12.2	14.7	1,898	33.9	26.0	2,002	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	141.5	126.0	14,806	141.5	126.0	14,806
Residual[2]	64.6	57.8	7,386	8.2	10.0	1,285	22.9	17.6	1,355	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	4.0	6.1	849	95.8	85.3	10,026	99.8	91.4	10,876
Non-Target[3]	17.3	45.0	7,078	13.8	44.8	8,700	25.7	31.5	3,014	13.9	15.0	2,153	2.4	1.1	95	7.8	5.9	499	1.1	3.3	464	1.1	2.1	260	82.0	146.6	22,003	83.1	148.7	22,263

TPA = trees/acre
BA = basal area/acre (sq ft)
BF = board feet/acre

[1]Removed Trees = trees that were harvested from shaded area
[2]Residual Trees = trees that were not harvested from shaded area
[3]Non-Target Trees = trees that were not harvested from non-shaded area

Data Collected: 11/2001

Ecological Thinning Unit E2 - Before Thin

700 Road Forest Habitat Restoration Project

Tree data by species

acres: 92.0

	Western Hemlock			Douglas Fir			Western Redcedar			Silver Fir			Noble Fir			Red Alder			Snags			Total Live			Total			Summary		
Size (dbh)	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF
6	22.3	4.3	203	4.0	0.9	80	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	26.3	5.1	283	26.3	5.1	283			
7	27.6	7.5	682	11.2	2.9	225	8.6	2.1	171	0.0	0.0	0	0.0	0.0	0	4.1	1.1	124	0.0	0.0	0	51.6	13.6	1,202	51.6	13.6	1,202			
8	37.0	12.5	1,104	3.2	1.1	63	3.2	1.1	63	0.0	0.0	0	0.0	0.0	0	3.7	1.1	111	0.0	0.0	0	47.0	15.8	1,341	47.0	15.8	1,341	227.5	82.6	6,863
9	39.4	16.9	1,480	2.1	0.8	84	14.5	5.9	425	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	56.0	23.6	1,989	56.0	23.6	1,989			
10	26.4	13.9	1,259	5.8	3.0	262	8.3	4.4	263	1.9	1.0	114	0.0	0.0	0	2.2	1.1	88	2.1	1.0	62	44.6	23.4	1,986	46.6	24.4	2,048			
11	27.0	17.5	1,715	4.4	3.0	293	3.6	2.4	141	0.0	0.0	0	0.0	0.0	0	1.6	1.1	98	0.0	0.0	0	36.6	23.9	2,247	36.6	23.9	2,247			
12	16.3	12.4	1,375	2.9	2.1	224	4.7	3.6	246	0.0	0.0	0	0.0	0.0	0	1.4	1.1	99	0.0	0.0	0	25.2	19.2	1,944	25.2	19.2	1,944			
13	25.1	22.4	2,760	8.1	7.3	820	7.6	6.7	535	3.6	3.2	325	0.0	0.0	0	3.8	3.3	329	0.0	0.0	0	48.3	42.9	4,769	48.3	42.9	4,769	147.0	126.6	13,624
14	8.1	8.4	962	8.0	8.4	985	3.4	3.4	258	1.1	1.1	138	0.0	0.0	0	1.1	1.1	114	0.0	0.0	0	21.7	22.3	2,457	21.7	22.3	2,457			
15	9.7	11.6	1,614	1.6	2.0	201	3.9	4.7	392	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	15.2	18.3	2,207	15.2	18.3	2,207			
16	5.3	7.3	997	4.5	6.0	733	4.0	5.6	543	0.0	0.0	0	0.6	0.8	143	0.0	0.0	0	0.0	0.0	0	14.5	19.8	2,416	14.5	19.8	2,416			
17	6.2	9.5	1,391	5.5	8.4	1,057	1.6	2.4	218	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	13.2	20.3	2,666	13.2	20.3	2,666			
18	0.0	0.0	0	5.6	9.5	1,293	3.4	5.9	616	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	9.0	15.5	1,909	9.0	15.5	1,909	51.9	86.4	11,241
19	1.1	2.2	304	3.7	7.1	1,034	1.8	3.4	394	0.6	1.0	144	0.0	0.0	0	0.6	1.1	129	0.0	0.0	0	7.8	14.8	2,005	7.8	14.8	2,005			
20	0.0	0.0	0	6.3	13.6	2,016	1.1	2.4	229	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	7.5	16.1	2,245	7.5	16.1	2,245			
21	0.9	2.1	329	2.1	5.1	917	1.0	2.4	277	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	4.0	9.6	1,523	4.0	9.6	1,523			
22	0.0	0.0	0	2.1	5.4	825	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	2.1	5.4	825	2.1	5.4	825			
23	0.0	0.0	0	3.0	8.5	1,508	0.9	2.5	248	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	3.8	11.0	1,756	3.8	11.0	1,756	10.9	29.3	4,711
24	0.0	0.0	0	0.3	1.1	205	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.3	1.1	205	0.3	1.1	205			
25	0.0	0.0	0	0.6	2.1	402	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.6	2.1	402	0.6	2.1	402			
26	0.0	0.0	0	0.6	2.2	404	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.6	2.2	404	0.6	2.2	404			
27	0.0	0.0	0	0.8	3.3	632	0.3	1.3	157	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	1.2	4.6	789	1.2	4.6	789			
28	0.0	0.0	0	0.3	1.1	207	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.3	1.1	207	0.3	1.1	207	2.2	8.9	1,629
29	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0			
30	0.0	0.0	0	0.2	1.1	229	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.2	1.1	229	0.2	1.1	229			
31	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0			
32	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.2	1.3	156
33	0.0	0.0	0	0.0	0.0	0	0.2	1.3	156	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.2	1.3	156	0.2	1.3	156			
Total	252.3	148.4	16,175	87.1	106.2	14,699	71.9	61.3	5,332	7.1	6.3	721	0.6	0.8	143	18.6	11.1	1,092	2.1	1.0	62	437.7	334.1	38,162	439.7	335.1	38,224	439.7	335.1	38,224

Pools

Target[1]	238.8	127.2	13,154	61.3	46.0	5,027	57.6	34.1	2,494	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	357.8	207.4	20,675	357.8	207.4	20,675
Non-Target[2]	13.5	21.1	3,021	25.8	60.2	9,672	14.3	27.2	2,838	7.1	6.3	721	0.6	0.8	143	18.6	11.1	1,092	2.1	1.0	62	79.9	126.7	17,487	82.0	127.7	17,549

TPA = trees/acre

BA = basal area/acre (sq ft)

BF = board feet/acre

[1]Target Pool = pool from which trees CAN be harvested (shaded area)

[2]Non-Target Pool = pool from which trees CANNOT be harvested (non-shaded area)

Snag Pool= pool from which trees CAN be used for snag creation (bold outline)

Data Collected: 11/2001

Ecological Thinning Area E2 - After 35% BA Thinning Applied to Target Species by DBH

700 Road Forest Habitat Restoration Project | Acres: 92

Tree data by species | BA Harvest: 35 | created snags/acre target: 4 | 14-17" dbh

	Western Hemlock			Douglas Fir			Western Redcedar			Silver Fir			Noble Fir			Red Alder			Snags			Total Live			Total			Summary		
Size (dbh)	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF
6	9.7	1.9	88	1.7	0.4	35	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	11.4	2.2	123	11.4	2.2	123			
7	12.0	3.3	296	4.9	1.3	98	3.7	0.9	74	0.0	0.0	0	0.0	0.0	0	4.1	1.1	124	0.0	0.0	0	24.8	6.5	592	24.8	6.5	592			
8	16.1	5.4	480	1.4	0.5	27	1.4	0.5	27	0.0	0.0	0	0.0	0.0	0	3.7	1.1	111	0.0	0.0	0	22.5	7.5	645	22.5	7.5	645	106.8	38.9	3,264
9	17.1	7.3	643	0.9	0.4	36	6.3	2.6	185	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	24.3	10.3	864	24.3	10.3	864			
10	11.5	6.0	547	2.5	1.3	114	3.6	1.9	114	1.9	1.0	114	0.0	0.0	0	2.2	1.1	88	2.1	1.0	62	21.7	11.4	977	23.7	12.4	1,039			
11	11.7	7.6	745	1.9	1.3	127	1.6	1.0	61	0.0	0.0	0	0.0	0.0	0	1.6	1.1	98	0.0	0.0	0	16.8	11.0	1,032	16.8	11.0	1,032			
12	7.1	5.4	597	1.2	0.9	97	2.0	1.5	107	0.0	0.0	0	0.0	0.0	0	1.4	1.1	99	0.0	0.0	0	11.7	9.0	901	11.7	9.0	901			
13	10.9	9.7	1,199	3.5	3.2	356	3.3	2.9	232	3.6	3.2	325	0.0	0.0	0	3.8	3.3	329	0.0	0.0	0	25.2	22.3	2,442	25.2	22.3	2,442	74.1	64.6	6,938
14	3.5	3.6	418	3.5	3.6	428	1.5	1.5	112	1.1	1.1	138	0.0	0.0	0	1.1	1.1	114	1.7	1.8	197	10.7	10.9	1,210	12.4	12.7	1,407			
15	4.2	5.0	701	0.7	0.9	87	1.7	2.0	170	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	1.4	1.6	198	6.6	7.9	959	8.0	9.6	1,157			
16	5.3	7.3	997	1.9	2.6	318	4.0	5.6	543	0.0	0.0	0	0.6	0.8	143	0.0	0.0	0	0.4	0.5	66	11.9	16.4	2,001	12.3	16.9	2,067			
17	6.2	9.5	1,391	2.4	3.7	459	1.6	2.4	218	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.5	0.8	95	10.1	15.5	2,068	10.6	16.3	2,163			
18	0.0	0.0	0	5.6	9.5	1,293	3.4	5.9	616	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	9.0	15.5	1,909	9.0	15.5	1,909	47.2	79.6	10,389
19	1.1	2.2	304	3.7	7.1	1,034	1.8	3.4	394	0.6	1.0	144	0.0	0.0	0	0.6	1.1	129	0.0	0.0	0	7.8	14.8	2,005	7.8	14.8	2,005			
20	0.0	0.0	0	6.3	13.6	2,016	1.1	2.4	229	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	7.5	16.1	2,245	7.5	16.1	2,245			
21	0.9	2.1	329	2.1	5.1	917	1.0	2.4	277	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	4.0	9.6	1,523	4.0	9.6	1,523			
22	0.0	0.0	0	2.1	5.4	825	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	2.1	5.4	825	2.1	5.4	825			
23	0.0	0.0	0	3.0	8.5	1,508	0.9	2.5	248	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	3.8	11.0	1,756	3.8	11.0	1,756	10.9	29.3	4,711
24	0.0	0.0	0	0.3	1.1	205	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.3	1.1	205	0.3	1.1	205			
25	0.0	0.0	0	0.6	2.1	402	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.6	2.1	402	0.6	2.1	402			
26	0.0	0.0	0	0.6	2.2	404	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.6	2.2	404	0.6	2.2	404			
27	0.0	0.0	0	0.8	3.3	632	0.3	1.3	157	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	1.2	4.6	789	1.2	4.6	789			
28	0.0	0.0	0	0.3	1.1	207	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.3	1.1	207	0.3	1.1	207	2.2	8.9	1,629
29	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0			
30	0.0	0.0	0	0.2	1.1	229	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.2	1.1	229	0.2	1.1	229			
31	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0			
32	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.2	1.3	156
33	0.0	0.0	0	0.0	0.0	0	0.2	1.3	156	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.2	1.3	156	0.2	1.3	156			
Total	117.3	76.4	8,736	52.4	80.2	11,856	39.3	42.0	3,922	7.1	6.3	721	0.6	0.8	143	18.6	11.1	1,092	6.1	5.7	617	235.4	216.8	26,470	241.4	222.5	27,088	241.4	222.5	27,088

Trees

	Western Hemlock			Douglas Fir			Western Redcedar			Silver Fir			Noble Fir			Red Alder			Snags			Total Live			Total		
Removed[1]	135.0	71.9	7,439	34.7	26.0	2,843	32.6	19.3	1,410	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	202.3	117.3	11,692	202.3	117.3	11,692
Residual[2]	103.8	55.3	5,715	26.7	20.0	2,184	25.0	14.8	1,084	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	4.0	4.7	555	155.5	90.1	8,983	159.5	94.8	9,539
Non-Target[3]	13.5	21.1	3,021	25.8	60.2	9,672	14.3	27.2	2,838	7.1	6.3	721	0.6	0.8	143	18.6	11.1	1,092	2.1	1.0	62	79.9	126.7	17,487	82.0	127.7	17,549

TPA = trees/acre

BA = basal area/acre (sq ft)

BF = board feet/acre

[1]Removed Trees = trees that were harvested from shaded area

[2]Residual Trees = trees that were not harvested from shaded area

[3]Non-Target Trees = trees that were not harvested from non-shaded area

Data Collected: 11/2001

Ecological Thinning Unit E3 - Before Thin

700 Road Forest Habitat Restoration Project

Tree data by species

acres: 47

	Western Hemlock			Douglas Fir			Western Redcedar			Silver Fir			Noble Fir			Red Alder			Snags			Total Live			Total			Summary		
Size (dbh)	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF
6	16.4	2.9	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	16.4	2.9	0	16.4	2.9	0			
7	47.4	12.7	944	10.5	3.0	314	13.5	3.4	271	10.5	3.0	210	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	81.9	22.1	1,739	81.9	22.1	1,739			
8	38.2	12.6	1,134	7.7	2.9	309	20.6	6.9	412	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	66.5	22.4	1,855	66.5	22.4	1,855	252.9	87.2	6,767
9	38.5	15.8	1,291	6.7	3.0	269	0.0	0.0	0	7.7	3.0	154	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	52.9	21.9	1,714	52.9	21.9	1,714			
10	11.6	6.0	464	17.3	8.8	742	0.0	0.0	0	6.3	3.1	253	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	35.2	17.9	1,459	35.2	17.9	1,459			
11	14.8	9.2	788	4.8	2.9	290	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	19.7	12.1	1,078	19.7	12.1	1,078			
12	7.9	6.2	554	3.9	3.0	271	4.6	3.6	183	4.0	3.1	356	0.0	0.0	0	0.0	0.0	0	4.7	3.7	140	20.3	16.0	1,364	25.0	19.6	1,504			
13	7.3	6.2	657	17.7	15.6	1,490	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	25.0	21.8	2,147	25.0	21.8	2,147	108.5	97.5	9,545
14	6.2	6.2	741	2.7	2.8	425	3.4	3.6	268	2.8	3.0	426	0.0	0.0	0	0.0	0.0	0	3.6	3.9	181	15.0	15.6	1,860	18.7	19.5	2,041			
15	7.7	9.2	1,003	12.6	15.3	1,772	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	20.2	24.5	2,775	20.2	24.5	2,775			
16	2.1	3.0	511	11.4	15.6	1,984	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	13.6	18.5	2,495	13.6	18.5	2,495			
17	4.1	6.2	894	6.1	9.3	1,259	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	10.2	15.5	2,153	10.2	15.5	2,153			
18	0.0	0.0	0	8.9	15.4	2,035	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	8.9	15.4	2,035	8.9	15.4	2,035	44.6	74.5	10,215
19	0.0	0.0	0	1.6	3.1	426	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	1.6	3.1	426	1.6	3.1	426			
20	1.5	3.2	399	8.8	18.8	2,707	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	10.4	22.0	3,106	10.4	22.0	3,106			
21	0.0	0.0	0	1.4	3.3	511	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	1.4	3.3	511	1.4	3.3	511			
22	0.0	0.0	0	2.6	7.0	794	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	2.6	7.0	794	2.6	7.0	794			
23	0.0	0.0	0	1.2	3.2	484	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	1.2	3.2	484	1.2	3.2	484	8.2	23.3	3,305
24	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	1.0	3.2	567	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	1.0	3.2	567	1.0	3.2	567			
25	0.0	0.0	0	2.0	6.7	949	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	2.0	6.7	949	2.0	6.7	949			
26	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0			
27	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0			
28	0.0	0.0	0	0.8	3.3	541	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.8	3.3	541	0.8	3.3	541	0.8	3.3	541
29	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0			
30	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0			
31	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0			
32	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0
33	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0			
Total	203.6	99.3	9,380	128.6	142.8	17,572	42.1	17.5	1,134	32.3	18.5	1,966	0.0	0.0	0	0.0	0.0	0	8.3	7.6	321	406.7	278.1	30,052	415.0	285.7	30,373	415.0	285.7	30,373

Pools

	WH TPA	WH BA	WH BF	DF TPA	DF BA	DF BF	WRC TPA	WRC BA	WRC BF	SF TPA	SF BA	SF BF	NF TPA	NF BA	NF BF	RA TPA	RA BA	RA BF	Snags TPA	Snags BA	Snags BF	Total Live TPA	Total Live BA	Total Live BF	Total TPA	Total BA	Total BF
Target[1]	203.6	99.3	9,380	128.6	142.8	17,572	42.1	17.5	1,134	32.3	18.5	1,966	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	406.7	278.1	30,052	406.7	278.1	30,052
Non-Target[2]	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	8.3	7.6	321	0.0	0.0	0	8.3	7.6	321

TPA = trees/acre

BA = basal area/acre (sq ft)

BF = board feet/acre

[1]Target Pool = pool from which trees CAN be harvested (shaded area)

[2]Non-Target Pool = pool from which trees CANNOT be harvested (non-shaded area)

Snag Pool= pool from which trees CAN be used for snag creation (bold outline)

Data Collected: 11/2001

Ecological Thinning Area E3 - After 30% BA Thinning Applied to Target Species Across DBH

700 Road Forest Habitat Restoration Project — Acres: 47

Tree data by species — %BA Harvest: 30 — created snags/acre target: 12 — >14"dbh

	Western Hemlock			Douglas Fir			Western Redcedar			Silver Fir			Noble Fir			Red Alder			Snags			Total Live			Total			Summary		
Size (dbh)	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF
6	11.3	2.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	11.3	2.0	0	11.3	2.0	0			
7	32.8	8.8	653	7.2	2.1	217	9.4	2.4	188	7.3	2.1	145	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	56.6	15.3	1,203	56.6	15.3	1,203			
8	26.4	8.7	785	5.3	2.0	214	14.3	4.8	285	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	46.0	15.5	1,284	46.0	15.5	1,284	175.0	60.3	4,682
9	26.6	11.0	893	4.7	2.1	186	0.0	0.0	0	5.3	2.1	107	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	36.6	15.1	1,186	36.6	15.1	1,186			
10	8.0	4.2	321	11.9	6.1	513	0.0	0.0	0	4.4	2.2	175	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	24.3	12.4	1,010	24.3	12.4	1,010			
11	10.3	6.4	545	3.3	2.0	201	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	13.6	8.4	746	13.6	8.4	746			
12	5.5	4.3	383	2.7	2.1	188	3.2	2.5	127	2.7	2.2	246	0.0	0.0	0	0.0	0.0	0	4.7	3.7	140	14.1	11.0	944	18.7	14.7	1,084			
13	5.0	4.3	455	12.2	10.8	1,031	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	17.3	15.1	1,486	17.3	15.1	1,486	80.9	73.7	7,155
14	4.3	4.3	513	1.8	2.0	294	2.3	2.5	185	2.0	2.1	295	0.0	0.0	0	0.0	0.0	0	3.6	3.9	181	10.4	10.8	1,287	14.0	14.7	1,468			
15	5.3	6.4	694	8.7	10.6	1,226	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	3.3	4.0	451	14.0	16.9	1,920	17.3	20.9	2,371			
16	1.5	2.1	354	7.9	10.8	1,373	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	2.2	3.0	406	9.4	12.8	1,726	11.6	15.8	2,132			
17	2.8	4.3	619	4.2	6.4	871	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	1.7	2.5	350	7.0	10.7	1,490	8.7	13.2	1,840			
18	0.0	0.0	0	6.2	10.7	1,408	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	1.5	2.5	331	6.2	10.7	1,408	7.6	13.2	1,739	38.1	63.7	8,729
19	0.0	0.0	0	1.1	2.2	295	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.3	0.5	69	1.1	2.2	295	1.3	2.7	364			
20	1.1	2.2	276	6.1	13.0	1,873	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	1.7	3.6	505	7.2	15.2	2,149	8.9	18.8	2,654			
21	0.0	0.0	0	1.0	2.3	354	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.2	0.5	83	1.0	2.3	354	1.2	2.8	437			
22	0.0	0.0	0	1.8	4.8	549	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.4	1.1	129	1.8	4.8	549	2.3	6.0	679			
23	0.0	0.0	0	0.8	2.2	335	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.2	0.5	79	0.8	2.2	335	1.0	2.7	414	7.0	19.9	2,824
24	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.7	2.2	392	0.0	0.0	0	0.0	0.0	0	0.2	0.5	92	0.7	2.2	392	0.9	2.7	485			
25	0.0	0.0	0	1.4	4.6	657	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.3	1.1	154	1.4	4.6	657	1.7	5.7	811			
26	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0			
27	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0			
28	0.0	0.0	0	0.5	2.3	374	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.1	0.5	88	0.5	2.3	374	0.7	2.8	462	0.7	2.8	462
29	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0			
30	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0			
31	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0			
32	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0
33	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0			
Total	140.9	68.7	6,490	89.0	98.8	12,159	29.1	12.1	785	22.4	12.8	1,360	0.0	0.0	0	0.0	0.0	0	20.3	28.0	3,059	281.4	192.4	20,794	301.7	220.4	23,853	301.7	220.4	23,853

Trees

	Western Hemlock			Douglas Fir			Western Redcedar			Silver Fir			Noble Fir			Red Alder			Snags			Total Live			Total		
Removed[1]	62.7	30.6	2,890	39.6	44.0	5,413	13.0	5.4	349	10.0	5.7	606	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	125.3	85.7	9,258	125.3	85.7	9,258
Residual[2]	140.9	68.7	6,490	89.0	98.8	12,159	29.1	12.1	785	22.4	12.8	1,360	0.0	0.0	0	0.0	0.0	0	12.0	20.4	2,738	281.4	192.4	20,794	293.4	212.8	23,532
Non-Target[3]	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	8.3	7.6	321	0.0	0.0	0	8.3	7.6	321

TPA = trees/acre

BA = basal area/acre (sq ft)

BF = board feet/acre

[1]Removed Trees = trees that were harvested from shaded area

[2]Residual Trees = trees that were not harvested from shaded area

[3]Non-Target Trees = trees that were not harvested from non-shaded area

Data Collected: 11/2001

Ecological Thinning Unit E4 - Before Thin

700 Road Forest Habitat Restoration Project

Tree data by species

acres: 21

	Western Hemlock			Douglas Fir			Western Redcedar			Silver Fir			Noble Fir			Red Alder			Snags			Total Live			Total			Summary		
Size (dbh)	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF
6	0.0	0.0	0	0.0	0.0	0	20.6	4.0	206	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	20.6	4.0	206	20.6	4.0	206			
7	47.1	11.6	746	15.4	3.8	308	15.5	4.1	309	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	77.9	19.5	1,363	77.9	19.5	1,363			
8	33.6	11.6	1,345	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	33.6	11.6	1,345	33.6	11.6	1,345	213.8	74.4	6,084
9	25.8	11.4	1,032	0.0	0.0	0	12.7	5.0	0	8.5	3.8	342	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	47.1	20.2	1,374	47.1	20.2	1,374			
10	34.6	19.1	1,796	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	34.6	19.1	1,796	34.6	19.1	1,796			
11	36.8	22.8	2,550	11.1	7.6	829	6.3	4.1	501	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	54.1	34.6	3,880	54.1	34.6	3,880			
12	45.0	34.3	4,182	5.2	3.8	471	6.5	4.7	452	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	56.6	42.7	5,105	56.6	42.7	5,105			
13	8.2	7.5	941	4.2	3.9	418	5.1	4.7	505	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	17.4	16.1	1,864	17.4	16.1	1,864	170.3	140.1	16,915
14	21.9	23.1	3,047	7.2	7.7	1,046	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	29.1	30.8	4,093	29.1	30.8	4,093			
15	9.2	11.3	1,783	0.0	0.0	0	3.8	4.7	190	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	13.0	16.0	1,973	13.0	16.0	1,973			
16	2.9	3.9	530	5.5	7.7	1,050	0.0	0.0	0	2.8	3.9	525	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	11.2	15.4	2,105	11.2	15.4	2,105			
17	2.4	3.9	514	4.9	7.7	1,077	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	7.3	11.6	1,591	7.3	11.6	1,591			
18	0.0	0.0	0	2.2	3.9	524	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	2.2	3.9	524	2.2	3.9	524	28.1	46.3	6,391
19	0.0	0.0	0	2.0	3.9	588	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	2.0	3.9	588	2.0	3.9	588			
20	1.8	3.9	495	3.6	7.7	1,088	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	5.4	11.6	1,583	5.4	11.6	1,583			
21	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0			
22	0.0	0.0	0	1.5	4.0	459	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	1.5	4.0	459	1.5	4.0	459			
23	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	1.5	4.0	459
24	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0			
25	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0			
26	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0			
27	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0			
28	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0
29	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0			
30	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0			
31	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0			
32	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0
33	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0			
Total	269.3	164.3	18,961	62.8	61.6	7,858	70.3	31.3	2,163	11.3	7.6	867	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	413.8	264.8	29,849	413.8	264.8	29,849	413.8	264.8	29,849

Pools

	Western Hemlock TPA	BA	BF	Douglas Fir TPA	BA	BF	Western Redcedar TPA	BA	BF	Silver Fir TPA	BA	BF	Noble Fir TPA	BA	BF	Red Alder TPA	BA	BF	Snags TPA	BA	BF	Total Live TPA	BA	BF	Total TPA	BA	BF
Target[1]	231.1	118.3	12,592	43.1	26.7	3,072	48.8	13.2	515	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	322.9	158.2	16,179	322.9	158.2	16,179
Non-Target[2]	38.2	46.0	6,369	19.7	34.9	4,786	21.6	18.1	1,648	11.3	7.6	867	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	90.8	106.6	13,670	90.8	106.6	13,670

TPA = trees/acre
BA = basal area/acre (sq ft)
BF = board feet/acre

[1]Target Pool = pool from which trees CAN be harvested (shaded area)
[2]Non-Target Pool = pool from which trees CANNOT be harvested (non-shaded area)
Snag Pool= pool from which trees CAN be used for snag creation (bold outline)

Data Collected: 11/2001

Ecological Thinning Area E4 - After 30% BA Thinning Applied to Target Species by DBH

700 Road Forest Habitat Restoration Project — Acres: 21

Tree data by species — %BA Harvested: 30 — created snags/acre target: 4 — 11-15"dbh

	Western Hemlock			Douglas Fir			Western Redcedar			Silver Fir			Noble Fir			Red Alder			Snags			Total Live			Total			Summary		
Size (dbh)	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF
6	0.0	0.0	0	0.0	0.0	0	10.2	2.0	103	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	10.2	2.0	103	10.2	2.0	103			
7	23.4	5.8	371	7.7	1.9	153	7.7	2.1	154	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	38.8	9.7	679	38.8	9.7	679			
8	16.7	5.8	670	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	16.7	5.8	670	16.7	5.8	670	110.8	38.9	3,201
9	12.8	5.7	514	0.0	0.0	0	6.3	2.5	0	8.5	3.8	342	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	27.7	11.9	856	27.7	11.9	856			
10	17.3	9.5	894	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	17.3	9.5	894	17.3	9.5	894			
11	18.3	11.4	1,270	5.5	3.8	413	6.3	4.1	501	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	1.6	1.0	115	30.1	19.3	2,183	31.7	20.3	2,298			
12	22.4	17.1	2,082	2.6	1.9	235	6.5	4.7	452	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	1.7	1.3	158	31.4	23.6	2,769	33.1	24.9	2,927			
13	4.1	3.8	469	2.1	1.9	208	5.1	4.7	505	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.4	0.4	46	11.2	10.3	1,182	11.6	10.7	1,228	115.2	99.1	12,029
14	21.9	23.1	3,047	3.6	3.8	521	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.2	0.3	36	25.4	26.9	3,568	25.7	27.2	3,603			
15	9.2	11.3	1,783	0.0	0.0	0	3.8	4.7	190	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	13.0	16.0	1,973	13.0	16.0	1,973			
16	2.9	3.9	530	5.5	7.7	1,050	0.0	0.0	0	2.8	3.9	525	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	11.2	15.4	2,105	11.2	15.4	2,105			
17	2.4	3.9	514	4.9	7.7	1,077	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	7.3	11.6	1,591	7.3	11.6	1,591			
18	0.0	0.0	0	2.2	3.9	524	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	2.2	3.9	524	2.2	3.9	524	28.1	46.3	6,391
19	0.0	0.0	0	2.0	3.9	588	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	2.0	3.9	588	2.0	3.9	588			
20	1.8	3.9	495	3.6	7.7	1,088	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	5.4	11.6	1,583	5.4	11.6	1,583			
21	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0			
22	0.0	0.0	0	1.5	4.0	459	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	1.5	4.0	459	1.5	4.0	459			
23	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	1.5	4.0	459
24	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0			
25	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0			
26	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0			
27	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0			
28	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0
29	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0			
30	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0			
31	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0			
32	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0
33	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0			
Total	153.3	104.9	12,638	41.2	48.2	6,316	45.8	24.7	1,904	11.3	7.6	867	0.0	0.0	0	0.0	0.0	0	4.0	3.0	355	251.6	185.4	21,725	255.6	188.4	22,080	255.6	188.4	22,080

Trees

	Western Hemlock			Douglas Fir			Western Redcedar			Silver Fir			Noble Fir			Red Alder			Snags			Total Live			Total		
Removed[1]	116.0	59.4	6,323	21.6	13.4	1,542	24.5	6.6	259	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	162.2	79.4	8,124	162.2	79.4	8,124
Residual[2]	115.1	58.9	6,269	21.5	13.3	1,530	24.3	6.6	256	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	4.0	3.0	355	160.8	78.8	8,055	164.8	81.8	8,410
Non-Target[3]	38.2	46.0	6,369	19.7	34.9	4,786	21.6	18.1	1,648	11.3	7.6	867	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	90.8	106.6	13,670	90.8	106.6	13,670

TPA = trees/acre
BA = basal area/acre (sq ft)
BF = board feet/acre

[1]Removed Trees = trees that were harvested from shaded area
[2]Residual Trees = trees that were not harvested from shaded area
[3]Non-Target Trees = trees that were not harvested from non-shaded area

Data Collected: 11/2001

Ecological Thinning Unit E5 - Before Thin

700 Road Forest Habitat Restoration Project

Tree data by species

acres: 36

	Western Hemlock			Douglas Fir			Western Redcedar			Silver Fir			Noble Fir			Red Alder			Snags			Total Live			Total			Summary		
Size (dbh)	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF
6	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0			
7	13.1	3.7	261	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	13.1	3.7	261	13.1	3.7	261			
8	20.0	7.0	592	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	20.0	7.0	592	20.0	7.0	592	85.2	34.9	2,812
9	25.5	10.4	841	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	25.5	10.4	841	25.5	10.4	841			
10	20.3	10.3	865	6.3	3.4	253	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	26.6	13.8	1,118	26.6	13.8	1,118			
11	5.6	3.4	336	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	5.6	3.4	336	5.6	3.4	336			
12	18.7	13.8	1,307	4.5	3.5	314	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	23.2	17.3	1,621	23.2	17.3	1,621			
13	3.7	3.4	486	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	3.7	3.4	486	3.7	3.4	486	50.8	45.0	5,062
14	0.0	0.0	0	6.4	6.9	967	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	6.4	6.9	967	6.4	6.9	967			
15	0.0	0.0	0	11.8	14.0	1,652	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	11.8	14.0	1,652	11.8	14.0	1,652			
16	2.4	3.4	530	7.7	10.6	1,342	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	10.1	13.9	1,872	10.1	13.9	1,872			
17	4.5	6.9	968	2.2	3.5	492	2.8	4.4	417	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	9.5	14.8	1,877	9.5	14.8	1,877			
18	4.1	7.3	907	8.2	14.0	1,753	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	12.3	21.3	2,660	12.3	21.3	2,660	53.3	92.6	11,888
19	0.0	0.0	0	14.6	28.1	3,667	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	14.6	28.1	3,667	14.6	28.1	3,667			
20	0.0	0.0	0	6.8	14.4	1,812	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	6.8	14.4	1,812	6.8	14.4	1,812			
21	0.0	0.0	0	6.2	14.7	1,801	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	6.2	14.7	1,801	6.2	14.7	1,801			
22	0.0	0.0	0	4.0	10.7	1,353	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	4.0	10.7	1,353	4.0	10.7	1,353			
23	0.0	0.0	0	3.8	10.6	1,587	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	3.8	10.6	1,587	3.8	10.6	1,587	17.3	46.8	6,358
24	0.0	0.0	0	1.2	3.7	505	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	1.2	3.7	505	1.2	3.7	505			
25	0.0	0.0	0	2.1	7.2	1,112	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	2.1	7.2	1,112	2.1	7.2	1,112			
26	0.0	0.0	0	1.1	3.9	451	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	1.1	3.9	451	1.1	3.9	451			
27	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0			
28	0.0	0.0	0	0.8	3.6	700	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.8	3.6	700	0.8	3.6	700	3.5	15.3	2,270
29	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0			
30	0.0	0.0	0	1.6	7.8	1,119	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	1.6	7.8	1,119	1.6	7.8	1,119			
31	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0			
32	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0
33	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0			
Total	118.0	69.6	7,093	89.4	160.7	20,880	2.8	4.4	417	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	210.1	234.6	28,390	210.1	234.6	28,390	210.1	234.6	28,390

Pools

Target[1]	84.5	34.8	2,895	61.8	84.1	10,440	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	146.2	118.9	13,335	146.2	118.9	13,335
Non-Target[2]	33.5	34.8	4,198	27.6	76.6	10,440	2.8	4.4	417	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	63.9	115.8	15,055	63.9	115.8	15,055

TPA = trees/acre

BA = basal area/acre (sq ft)

BF = board feet/acre

[1]Target Pool = pool from which trees CAN be harvested (shaded area)

[2]Non-Target Pool = pool from which trees CANNOT be harvested (non-shaded area)

Snag Pool= pool from which trees CAN be used for snag creation (bold outline)

Data Collected: 11/2001

Ecological Thinning Area E5 - After 30% BA Thinning Applied to Target Species by DBH

700 Road Forest Habitat Restoration Project Acres: 36

Tree data by species %BA Harvested: 30 created snags/acre target 4 15-19" dbh

	Western Hemlock			Douglas Fir			Western Redcedar			Silver Fir			Noble Fir			Red Alder			Snags			Total Live			Total			Summary		
Size (dbh)	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF
6	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0			
7	5.3	1.5	106	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	5.3	1.5	106	5.3	1.5	106			
8	8.1	2.8	241	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	8.1	2.8	241	8.1	2.8	241	34.7	14.2	1,147
9	10.4	4.3	343	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	10.4	4.3	343	10.4	4.3	343			
10	8.3	4.2	353	2.6	1.4	103	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	10.9	5.6	456	10.9	5.6	456			
11	2.3	1.4	137	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	2.3	1.4	137	2.3	1.4	137			
12	18.7	13.8	1,307	1.8	1.4	128	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	20.6	15.2	1,435	20.6	15.2	1,435			
13	3.7	3.4	486	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	3.7	3.4	486	3.7	3.4	486	35.1	29.8	3,275
14	0.0	0.0	0	2.6	2.8	394	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	2.6	2.8	394	2.6	2.8	394			
15	0.0	0.0	0	4.8	5.7	674	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	1.1	1.3	148	4.8	5.7	674	5.9	7.0	822			
16	2.4	3.4	530	3.2	4.3	547	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.7	0.9	121	5.6	7.7	1,077	6.3	8.6	1,198			
17	4.5	6.9	968	0.9	1.4	201	2.8	4.4	417	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.2	0.3	44	8.2	12.7	1,586	8.4	13.0	1,630			
18	4.1	7.3	907	3.3	5.7	715	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.7	1.3	157	7.5	13.0	1,622	8.2	14.3	1,780	36.9	64.4	8,245
19	0.0	0.0	0	5.9	11.5	1,496	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	1.3	2.5	329	5.9	11.5	1,496	7.3	14.0	1,825			
20	0.0	0.0	0	6.8	14.4	1,812	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	6.8	14.4	1,812	6.8	14.4	1,812			
21	0.0	0.0	0	6.2	14.7	1,801	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	6.2	14.7	1,801	6.2	14.7	1,801			
22	0.0	0.0	0	4.0	10.7	1,353	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	4.0	10.7	1,353	4.0	10.7	1,353			
23	0.0	0.0	0	3.8	10.6	1,587	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	3.8	10.6	1,587	3.8	10.6	1,587	17.3	46.8	6,358
24	0.0	0.0	0	1.2	3.7	505	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	1.2	3.7	505	1.2	3.7	505			
25	0.0	0.0	0	2.1	7.2	1,112	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	2.1	7.2	1,112	2.1	7.2	1,112			
26	0.0	0.0	0	1.1	3.9	451	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	1.1	3.9	451	1.1	3.9	451			
27	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0			
28	0.0	0.0	0	0.8	3.6	700	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.8	3.6	700	0.8	3.6	700	3.5	15.3	2,270
29	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0			
30	0.0	0.0	0	1.6	7.8	1,119	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	1.6	7.8	1,119	1.6	7.8	1,119			
31	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0			
32	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0
33	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0			
Total	68.0	49.0	5,379	52.8	110.9	14,699	2.8	4.4	417	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	4.0	6.3	800	123.5	164.2	20,495	127.5	170.6	21,294	127.5	170.6	21,294

Trees

Removed[1]	50.0	20.6	1,714	36.6	49.8	6,181	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	86.6	70.4	7,895	86.6	70.4	7,895
Residual[2]	34.5	14.2	1,181	25.2	34.3	4,259	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	4.0	6.3	800	59.7	48.5	5,440	63.7	54.8	6,239
Non-Target[3]	33.5	34.8	4,198	27.6	76.6	10,440	2.8	4.4	417	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	63.9	115.8	15,055	63.9	115.8	15,055

TPA = trees/acre
BA = basal area/acre (sq ft)
BF = board feet/acre

[1]Removed Trees = trees that were harvested from shaded area
[2]Residual Trees = trees that were not harvested from shaded area
[3]Non-Target Trees = trees that were not harvested from non-shaded area

Data Collected: 11/2001

Ecological Thinning Unit E6 - Before Thin

700 Road Forest Habitat Restoration Project

Tree data by species

acres: 85

Size	Western Hemlock			Douglas Fir			Western Redcedar			Silver Fir			Noble Fir			Red Alder			Snags			Total Live			Total			Summary		
(dbh)	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF
6	45.8	9.2	494	4.7	1.1	95	5.9	1.3	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	56.4	11.6	589	56.4	11.6	589			
7	56.4	14.6	1,280	5.4	1.3	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	4.9	1.3	99	0.0	0.0	0	66.7	17.2	1,379	66.7	17.2	1,379			
8	56.1	19.8	1,859	0.0	0.0	0	8.2	2.8	207	3.5	1.2	106	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	67.9	23.8	2,172	67.9	23.8	2,172	249.1	80.6	6,936
9	20.1	8.6	687	0.0	0.0	0	0.0	0.0	0	2.9	1.3	114	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	23.0	9.9	801	23.0	9.9	801			
10	26.1	13.5	1,528	8.9	4.7	467	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	35.0	18.2	1,995	35.0	18.2	1,995			
11	29.2	18.6	2,069	8.1	5.0	437	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	37.3	23.6	2,506	37.3	23.6	2,506			
12	21.3	16.1	1,950	1.6	1.3	115	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	1.7	1.4	120	0.0	0.0	0	24.7	18.8	2,185	24.7	18.8	2,185			
13	16.4	14.8	1,780	4.3	3.8	373	6.1	5.5	367	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	26.8	24.0	2,520	26.8	24.0	2,520	133.2	115.3	13,590
14	22.6	23.4	3,026	5.4	5.8	733	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	28.0	29.2	3,759	28.0	29.2	3,759			
15	12.4	14.8	2,001	4.1	5.0	619	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	16.4	19.8	2,620	16.4	19.8	2,620			
16	7.3	9.9	1,326	3.7	5.0	694	1.3	1.7	63	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	12.2	16.6	2,083	12.2	16.6	2,083			
17	8.1	12.5	1,626	5.6	8.7	1,185	0.9	1.5	156	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	14.6	22.6	2,967	14.6	22.6	2,967			
18	2.9	5.1	712	4.3	7.5	1,039	0.8	1.4	113	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	8.0	13.9	1,864	8.0	13.9	1,864	47.8	79.4	10,490
19	2.6	5.0	634	3.3	6.3	851	0.8	1.5	77	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	6.7	12.8	1,562	6.7	12.8	1,562			
20	2.9	6.1	919	3.5	7.5	1,095	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	6.3	13.5	2,014	6.3	13.5	2,014			
21	0.5	1.2	169	3.8	8.9	1,284	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	4.3	10.1	1,453	4.3	10.1	1,453			
22	0.5	1.2	196	2.4	6.2	1,059	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	2.8	7.4	1,255	2.8	7.4	1,255			
23	0.0	0.0	0	1.8	5.1	858	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	1.8	5.1	858	1.8	5.1	858	11.6	31.4	5,049
24	0.4	1.2	216	0.8	2.6	452	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	1.2	3.8	668	1.2	3.8	668			
25	0.0	0.0	0	1.5	5.1	815	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	1.5	5.1	815	1.5	5.1	815			
26	0.0	0.0	0	1.8	6.4	1,200	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	1.8	6.4	1,200	1.8	6.4	1,200			
27	0.0	0.0	0	1.0	4.0	768	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	1.0	4.0	768	1.0	4.0	768			
28	0.0	0.0	0	0.6	2.5	460	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.6	2.5	460	0.6	2.5	460	3.6	14.1	2,650
29	0.3	1.3	222	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.3	1.3	222	0.3	1.3	222			
30	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0			
31	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0			
32	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0
33	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0			
Total	331.8	196.8	22,694	76.5	103.3	14,599	24.0	15.5	983	6.4	2.5	220	0.0	0.0	0	6.7	2.7	219	0.0	0.0	0	445.3	320.8	38,715	445.3	320.8	38,715	445.3	320.8	38,715

Pools

	Western Hemlock TPA	BA	BF	Douglas Fir TPA	BA	BF	Western Redcedar TPA	BA	BF	Silver Fir TPA	BA	BF	Noble Fir TPA	BA	BF	Red Alder TPA	BA	BF	Snags TPA	BA	BF	Total Live TPA	BA	BF	Total TPA	BA	BF
Target[1]	294.2	138.6	14,673	51.8	41.5	4,718	6.1	5.5	367	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	352.1	185.5	19,758	352.1	185.5	19,758
Non-Target[2]	37.6	58.2	8,021	24.6	61.8	9,881	17.9	10.1	616	6.4	2.5	220	0.0	0.0	0	6.7	2.7	219	0.0	0.0	0	93.2	135.3	18,957	93.2	135.3	18,957

TPA = trees/acre

BA = basal area/acre (sq ft)

BF = board feet/acre

[1]Target Pool = pool from which trees CAN be harvested (shaded area)

[2]Non-Target Pool = pool from which trees CANNOT be harvested (non-shaded area)

Snag Pool= pool from which trees CAN be used for snag creation (bold outline)

Data Collected: 11/2001

Ecological Thinning Area E6 - After 35% BA Thinning Applied to Target Species by DBH

700 Road Forest Habitat Restoration Project — Acres: 85

Tree data by species — %BA Harvested: 35 — created snags/acre target: 4 14-17" dbh

	Western Hemlock			Douglas Fir			Western Redcedar			Silver Fir			Noble Fir			Red Alder			Snags			Total Live			Total			Summary		
Size (dbh)	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF
6	18.1	3.6	195	1.9	0.4	37	5.9	1.3	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	25.9	5.3	232	25.9	5.3	232			
7	22.3	5.8	505	2.1	0.5	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	4.9	1.3	99	0.0	0.0	0	29.3	7.6	604	29.3	7.6	604			
8	22.2	7.8	734	0.0	0.0	0	8.2	2.8	207	3.5	1.2	106	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	33.9	11.8	1,047	33.9	11.8	1,047	113.7	36.6	3,056
9	7.9	3.4	271	0.0	0.0	0	0.0	0.0	0	2.9	1.3	114	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	10.8	4.7	385	10.8	4.7	385			
10	10.3	5.3	603	3.5	1.9	184	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	13.8	7.2	787	13.8	7.2	787			
11	11.5	7.3	817	3.2	2.0	172	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	14.7	9.3	989	14.7	9.3	989			
12	8.4	6.4	770	0.6	0.5	45	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	1.7	1.4	120	0.0	0.0	0	10.8	8.2	935	10.8	8.2	935			
13	6.5	5.8	703	1.7	1.5	147	2.4	2.2	145	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	10.6	9.5	995	10.6	9.5	995	64.2	58.6	7,071
14	8.9	9.2	1,194	2.1	2.3	289	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	2.7	2.8	363	11.1	11.5	1,484	13.8	14.3	1,847			
15	12.4	14.8	2,001	1.6	2.0	244	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.4	0.5	60	14.0	16.8	2,245	14.4	17.3	2,305			
16	7.3	9.9	1,326	1.5	2.0	274	1.3	1.7	63	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.4	0.5	67	10.0	13.5	1,663	10.3	14.0	1,730			
17	8.1	12.5	1,626	2.2	3.4	468	0.9	1.5	156	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.5	0.8	114	11.2	17.4	2,250	11.7	18.2	2,364			
18	2.9	5.1	712	4.3	7.5	1,039	0.8	1.4	113	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	8.0	13.9	1,864	8.0	13.9	1,864	43.0	72.4	9,534
19	2.6	5.0	634	3.3	6.3	851	0.8	1.5	77	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	6.7	12.8	1,562	6.7	12.8	1,562			
20	2.9	6.1	919	3.5	7.5	1,095	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	6.3	13.5	2,014	6.3	13.5	2,014			
21	0.5	1.2	169	3.8	8.9	1,284	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	4.3	10.1	1,453	4.3	10.1	1,453			
22	0.5	1.2	196	2.4	6.2	1,059	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	2.8	7.4	1,255	2.8	7.4	1,255			
23	0.0	0.0	0	1.8	5.1	858	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	1.8	5.1	858	1.8	5.1	858	11.6	31.4	5,049
24	0.4	1.2	216	0.8	2.6	452	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	1.2	3.8	668	1.2	3.8	668			
25	0.0	0.0	0	1.5	5.1	815	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	1.5	5.1	815	1.5	5.1	815			
26	0.0	0.0	0	1.8	6.4	1,200	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	1.8	6.4	1,200	1.8	6.4	1,200			
27	0.0	0.0	0	1.0	4.0	768	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	1.0	4.0	768	1.0	4.0	768			
28	0.0	0.0	0	0.6	2.5	460	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.6	2.5	460	0.6	2.5	460	3.6	14.1	2,650
29	0.3	1.3	222	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.3	1.3	222	0.3	1.3	222			
30	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0			
31	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0			
32	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0
33	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0			
Total	153.8	112.9	13,813	45.1	78.2	11,743	20.3	12.2	761	6.4	2.5	220	0.0	0.0	0	6.7	2.7	219	4.0	4.6	604	232.2	208.5	26,756	236.2	213.1	27,360	236.2	213.1	27,360

Trees

Removed[1]	178.1	83.9	8,881	31.4	25.1	2,856	3.7	3.3	222	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	213.1	112.3	11,959	213.1	112.3	11,959
Residual[2]	116.1	54.7	5,792	20.5	16.4	1,862	2.4	2.2	145	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	4.0	4.6	604	139.0	73.2	7,799	143.0	77.8	8,403
Non-Target[3]	37.6	58.2	8,021	24.6	61.8	9,881	17.9	10.1	616	6.4	2.5	220	0.0	0.0	0	6.7	2.7	219	0.0	0.0	0	93.2	135.3	18,957	93.2	135.3	18,957

TPA = trees/acre
BA = basal area/acre (sq ft)
BF = board feet/acre

[1]Removed Trees = trees that were harvested from shaded area
[2]Residual Trees = trees that were not harvested from shaded area
[3]Non-Target Trees = trees that were not harvested from non-shaded area

Data Collected: 11/2001

Ecological Thinning Unit E7 - Before Thin
700 Road Forest Habitat Restoration Project
Tree data by species
acres: 19

Size	Western Hemlock			Douglas Fir			Western Redcedar			Silver Fir			Noble Fir			Red Alder			Snags			Total Live			Total			Summary		
(dbh)	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF
6	53.4	10.7	687	20.9	3.7	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	74.3	14.4	687	74.3	14.4	687			
7	60.3	15.2	1,282	0.0	0.0	0	16.4	4.4	328	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	76.7	19.6	1,610	76.7	19.6	1,610			
8	34.0	10.6	1,020	21.7	8.1	537	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	55.7	18.7	1,557	55.7	18.7	1,557	346.3	119.7	8,968
9	42.7	18.5	1,361	25.6	11.7	843	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	68.3	30.1	2,204	68.3	30.1	2,204			
10	36.6	19.1	1,594	34.7	17.8	1,316	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	71.3	36.9	2,910	71.3	36.9	2,910			
11	17.4	11.5	1,153	6.5	4.3	259	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	23.9	15.8	1,412	23.9	15.8	1,412			
12	4.8	3.5	384	9.5	7.5	333	6.4	4.6	191	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	20.7	15.6	908	20.7	15.6	908			
13	0.0	0.0	0	17.3	15.0	924	5.0	4.3	250	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	22.3	19.3	1,174	22.3	19.3	1,174	77.4	62.2	4,719
14	4.5	4.5	544	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	4.5	4.5	544	4.5	4.5	544			
15	0.0	0.0	0	6.0	7.1	681	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	6.0	7.1	681	6.0	7.1	681			
16	2.5	3.5	355	0.0	0.0	0	3.3	4.4	200	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	5.9	7.9	555	5.9	7.9	555			
17	3.0	4.4	504	0.0	0.0	0	2.9	4.6	234	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	5.9	9.0	738	5.9	9.0	738			
18	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	11.8	16.9	1,293
19	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0			
20	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0			
21	1.9	4.5	675	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	1.9	4.5	675	1.9	4.5	675			
22	1.7	4.4	784	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	1.7	4.4	784	1.7	4.4	784			
23	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	3.5	8.9	1,459
24	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0			
25	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0			
26	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0			
27	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0			
28	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0
29	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0			
30	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0			
31	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0			
32	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0
33	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0			
Total	262.8	110.4	10,343	142.2	75.1	4,893	34.0	22.2	1,203	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	439.0	207.8	16,439	439.0	207.8	16,439	439.0	207.8	16,439

Pools

	Western Hemlock TPA	BA	BF	Douglas Fir TPA	BA	BF	Western Redcedar TPA	BA	BF	Silver Fir TPA	BA	BF	Noble Fir TPA	BA	BF	Red Alder TPA	BA	BF	Snags TPA	BA	BF	Total Live TPA	BA	BF	Total TPA	BA	BF
Target[1]	227.0	74.1	5,944	102.9	41.2	2,696	6.4	4.6	191	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	336.3	119.9	8,831	336.3	119.9	8,831
Non-Target[2]	35.8	36.3	4,399	39.3	33.9	2,197	27.6	17.6	1,012	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	102.7	87.8	7,608	102.7	87.8	7,608

TPA = trees/acre
BA = basal area/acre (sq ft)
BF = board feet/acre

[1]Target Pool = pool from which trees CAN be harvested (shaded area)
[2]Non-Target Pool = pool from which trees CANNOT be harvested (non-shaded area)
Snag Pool= pool from which trees CAN be used for snag creation (bold outline)

Data Collected: 11/2001

Ecological Thinning Area E7 - After 35% BA Thinning Applied to Target Species by DBH

700 Road Forest Habitat Restoration Project — Acres: 19

Tree data by species — %BA Harvested: 35 — created snags/acre target: 4 10-12" dbh

	Western Hemlock			Douglas Fir			Western Redcedar			Silver Fir			Noble Fir			Red Alder			Snags			Total Live			Total			Summary		
Size (dbh)	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF
6	21.0	4.2	270	8.2	1.5	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	29.2	5.7	270	29.2	5.7	270			
7	23.7	6.0	505	0.0	0.0	0	16.4	4.4	328	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	40.1	10.4	833	40.1	10.4	833			
8	13.4	4.2	402	8.5	3.2	211	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	21.9	7.4	613	21.9	7.4	613	149.9	51.7	3,879
9	16.8	7.3	536	10.1	4.6	332	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	26.9	11.9	868	26.9	11.9	868			
10	14.4	7.5	628	13.7	7.0	518	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	3.7	1.9	150	28.1	14.5	1,146	31.7	16.4	1,296			
11	17.4	11.5	1,153	6.5	4.3	259	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	23.9	15.8	1,412	23.9	15.8	1,412			
12	4.8	3.5	384	9.5	7.5	333	2.5	1.8	75	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.3	0.2	10	16.8	12.8	792	17.2	13.0	802			
13	0.0	0.0	0	17.3	15.0	924	5.0	4.3	250	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	22.3	19.3	1,174	22.3	19.3	1,174	73.9	59.7	4,613
14	4.5	4.5	544	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	4.5	4.5	544	4.5	4.5	544			
15	0.0	0.0	0	6.0	7.1	681	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	6.0	7.1	681	6.0	7.1	681			
16	2.5	3.5	355	0.0	0.0	0	3.3	4.4	200	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	5.9	7.9	555	5.9	7.9	555			
17	3.0	4.4	504	0.0	0.0	0	2.9	4.6	234	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	5.9	9.0	738	5.9	9.0	738			
18	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	11.8	16.9	1,293
19	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0			
20	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0			
21	1.9	4.5	675	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	1.9	4.5	675	1.9	4.5	675			
22	1.7	4.4	784	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	1.7	4.4	784	1.7	4.4	784			
23	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	3.5	8.9	1,459
24	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0			
25	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0			
26	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0			
27	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0			
28	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0
29	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0			
30	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0			
31	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0			
32	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0
33	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0			
Total	125.2	65.5	6,739	79.8	50.1	3,258	30.2	19.4	1,087	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	4.0	2.1	160	235.1	135.0	11,085	239.1	137.2	11,245	239.1	137.2	11,245

Trees

Removed[1]	137.6	44.9	3,604	62.4	25.0	1,635	3.9	2.8	116	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	203.9	72.7	5,354	203.9	72.7	5,354
Residual[2]	89.4	29.2	2,340	40.5	16.2	1,061	2.5	1.8	75	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	4.0	2.1	160	132.4	47.2	3,477	136.4	49.4	3,637
Non-Target[3]	35.8	36.3	4,399	39.3	33.9	2,197	27.6	17.6	1,012	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	102.7	87.8	7,608	102.7	87.8	7,608

TPA = trees/acre
BA = basal area/acre (sq ft)
BF = board feet/acre

[1]Removed Trees = trees that were harvested from shaded area
[2]Residual Trees = trees that were not harvested from shaded area
[3]Non-Target Trees = trees that were not harvested from non-shaded area

Data Collected: 11/2001

Ecological Thinning Unit E8 - Before Thin

700 Road Forest Habitat Restoration Project

Tree data by species

acres: 15

Size (dbh)	Western Hemlock			Douglas Fir			Western Redcedar			Pacific Silver Fir			Snags			Total			Summary		
	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF
6	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0			
7	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0			
8	70.5	22.5	1,874	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	70.5	22.5	1,874	165.1	66.1	5,586
9	37.0	14.6	1,298	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	37.0	14.6	1,298			
10	44.3	21.8	1,620	13.2	7.2	794	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	57.6	29.0	2,414			
11	24.3	14.6	1,456	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	24.3	14.6	1,456			
12	9.4	7.4	658	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	9.4	7.4	658			
13	49.5	44.4	5,932	0.0	0.0	0	8.6	7.9	601	0.0	0.0	0	0.0	0.0	0	58.1	52.4	6,533	118.2	104.4	12,454
14	0.0	0.0	0	0.0	0.0	0	8.0	7.9	557	0.0	0.0	0	0.0	0.0	0	8.0	7.9	557			
15	18.5	22.1	3,250	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	18.5	22.1	3,250			
16	16.5	22.5	3,180	10.6	14.9	2,110	5.5	7.9	718	0.0	0.0	0	0.0	0.0	0	32.5	45.3	6,008			
17	9.8	14.9	2,098	4.9	7.7	1,078	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	14.7	22.7	3,176			
18	4.3	7.6	1,025	4.3	7.6	1,282	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	8.5	15.1	2,307	71.3	114.4	16,102
19	0.0	0.0	0	4.0	7.6	1,213	4.1	8.1	1,111	0.0	0.0	0	0.0	0.0	0	8.2	15.7	2,324			
20	0.0	0.0	0	3.5	7.6	1,350	3.9	8.1	937	0.0	0.0	0	0.0	0.0	0	7.4	15.7	2,287			
21	0.0	0.0	0	6.4	15.3	2,950	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	6.4	15.3	2,950			
22	0.0	0.0	0	3.1	7.7	1,410	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	3.1	7.7	1,410			
23	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	2.6	7.6	1,622	0.0	0.0	0	2.6	7.6	1,622	12.0	30.6	5,982
24	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0			
25	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0			
26	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0	2.0	7.9	1,273
27	0.0	0.0	0	2.0	7.9	1,273	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0.0	2.0	7.9	1,273			
Total	284.0	192.4	22,391	51.9	83.4	13,460	30.1	39.9	3,924	2.6	7.6	1,622	0.0	0.0	0	368.6	323.3	41,397			

Pools

Target[1]	235.0	125.3	12,838	13.2	7.2	794	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0.0	248.3	132.5	13,632
Non-Target[2]	49.0	67.1	9,553	38.6	76.2	12,666	30.1	39.9	3,924	2.6	7.6	1,622	0.0	0.0	0.0	120.3	190.8	27,765

TPA = trees/acre

BA = basal area/acre (sq ft)

BF = board feet/acre

[1]Target Pool = pool from which trees CAN be harvested (shaded area)

[2]Non-Target Pool = pool from which trees CANNOT be harvested (non-shaded area)

Snag Pool= pool from which trees CAN be used for snag creation (bold outline)

Data Collected: 11/2001

Ecological Thinning Unit E8 - After 35% BA Thinning Applied to Smallest Western Hemlock and Douglas-fir

700 Road Forest Habitat Restoration Project

Tree data by species

Acres: 15

%BA Harvested: 35

created snags/acre target: 4 — 13" dbh

Size (dbh)	Western Hemlock			Douglas Fir			Western Redcedar			Pacific Silver Fir			Snags			Total Live Trees			Summary		
	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF
6	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0			
7	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0			
8	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0
9	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0			
10	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0			
11	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0			
12	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0			
13	21.5	19.3	2,580	0.0	0.0	0	8.6	7.9	601	0.0	0.0	0	4.0	3.6	479	30.1	27.2	3,181	56.5	57.3	6,988
14	0.0	0.0	0	0.0	0.0	0	8.0	7.9	557	0.0	0.0	0	0.0	0.0	0	8.0	7.9	557			
15	18.5	22.1	3,250	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	18.5	22.1	3,250			
16	16.5	22.5	3,180	10.6	14.9	2,110	5.5	7.9	718	0.0	0.0	0	0.0	0.0	0	32.5	45.3	6,008			
17	9.8	14.9	2,098	4.9	7.7	1,078	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	14.7	22.7	3,176			
18	4.3	7.6	1,025	4.3	7.6	1,282	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	8.5	15.1	2,307	71.3	114.4	16,102
19	0.0	0.0	0	4.0	7.6	1,213	4.1	8.1	1,111	0.0	0.0	0	0.0	0.0	0	8.2	15.7	2,324			
20	0.0	0.0	0	3.5	7.6	1,350	3.9	8.1	937	0.0	0.0	0	0.0	0.0	0	7.4	15.7	2,287			
21	0.0	0.0	0	6.4	15.3	2,950	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	6.4	15.3	2,950			
22	0.0	0.0	0	3.1	7.7	1,410	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	3.1	7.7	1,410			
23	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	2.6	7.6	1,622	0.0	0.0	0	2.6	7.6	1,622	12.0	30.6	5,982
24	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0			
25	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0			
26	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	2.0	7.9	1,273
27	0.0	0.0	0	2.0	7.9	1,273	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	2.0	7.9	1,273			
Total	70.5	86.4	12,133	38.6	76.2	12,666	30.1	39.9	3,924	2.6	7.6	1,622	4.0	3.6	479	141.8	210.1	30,345			

Trees

Removed[1]	209.5	106.0	10,258	13.2	7.2	794	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	222.7	113.2	11,052
Residual[2]	21.5	19.3	2,580	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	4.0	3.6	479	21.5	19.3	2,580
Non-Target[3]	49.0	67.1	9,553	38.6	76.2	12,666	30.1	39.9	3,924	2.6	7.6	1,622	0.0	0.0	0.0	120.3	190.8	27,765

TPA = trees/acre

BA = basal area/acre (sq ft)

BF = board feet/acre

[1]Removed Trees = trees that were harvested from shaded area

[2]Residual Trees = trees that were not harvested from shaded area

[3]Non-Target Trees = trees that were not harvested from non-shaded area

Data Collected: 11/2001

Restoration Thinning Unit RT - Before Thin
700 Road Forest Habitat Restoration Project
Tree data by species
acres: 14

Size (dbh)	Western Hemlock TPA	Western Hemlock BA	Douglas Fir TPA	Douglas Fir BA	Western Redcedar TPA	Western Redcedar BA	Silver Fir TPA	Silver Fir BA	Noble Fir TPA	Noble Fir BA	Red Alder TPA	Red Alder BA	Snags TPA	Snags BA	Total Live TPA	Total Live BA	Total TPA	Total BA
6	67.9	12.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	67.9	12.9	67.9	12.9
7	51.1	13.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	51.1	13.1	51.1	13.1
8	24.6	8.6	39.3	13.1	13.0	4.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	76.9	26.2	76.9	26.2
9	0.0	0.0	41.6	18.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	41.6	18.4	41.6	18.4
10	23.3	12.7	16.8	8.7	11.8	5.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	51.9	27.2	51.9	27.2
11	6.4	4.2	15.6	9.4	8.5	5.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	30.5	18.7	30.5	18.7
12	0.0	0.0	11.4	8.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	11.4	8.6	11.4	8.6
13	0.0	0.0	15.3	13.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	15.3	13.0	15.3	13.0
14	0.0	0.0	13.4	13.6	12.6	13.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	26.0	26.6	26.0	26.6
15	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
16	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
17	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
18	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
19	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
21	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
22	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
23	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
24	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
25	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
26	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
27	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
28	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
29	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
30	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
31	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
32	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
33	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	173.4	51.6	153.3	84.8	45.9	28.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	372.6	164.8	372.6	164.8

Pools

Target[1]	143.6	34.6	97.7	40.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	241.3	74.8	241.3	74.8
Non-Target[2]	29.8	17.0	55.7	44.6	45.9	28.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	131.3	90.0	131.3	90.0

TPA = trees/acre
BA = basal area/acre (sq ft)

[1]Target Pool = pool from which trees CAN be harvested (shaded area)
[2]Non-Target Pool = pool from which trees CANNOT be harvested (non-shaded area)

Data Collected: 11/2001

Restoration Thinning Unit RT - After Thin

700 Road Forest Habitat Restoration Project — acres: 14

Tree data by species — %BA Harvested: 32

Size	Western Hemlock		Douglas Fir		Western Redcedar		Silver Fir		Noble Fir		Red Alder		Snags		Total Live		Total	
(dbh)	TPA	BA	TPA	BA	TPA	BA	TPA	BA	TPA	BA	TPA	BA	TPA	BA	TPA	BA	TPA	BA
6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8	24.6	8.6	0.0	0.0	13.0	4.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	37.6	13.1	37.6	13.1
9	0.0	0.0	21.0	9.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	21.0	9.2	21.0	9.2
10	23.3	12.7	8.0	4.3	11.8	5.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	43.2	22.9	43.2	22.9
11	6.4	4.2	15.6	9.4	8.5	5.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	30.5	18.7	30.5	18.7
12	0.0	0.0	11.4	8.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	11.4	8.6	11.4	8.6
13	0.0	0.0	15.3	13.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	15.3	13.0	15.3	13.0
14	0.0	0.0	13.4	13.6	12.6	13.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	26.0	26.6	26.0	26.6
15	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
16	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
17	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
18	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
19	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
21	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
22	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
23	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
24	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
25	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
26	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
27	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
28	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
29	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
30	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
31	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
32	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
33	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	54.4	25.6	84.7	58.1	45.9	28.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	184.9	112.1	184.9	112.1

TPA = trees/acre

BA = basal area/acre (sq ft)

Data Collected: 11/2001

Leave Unit L2
700 Road Forest Habitat Restoration Project
Tree data by species
acres: 28

Size	Western Hemlock			Douglas Fir			Western Redcedar			Silver Fir			Noble Fir			Red Alder			Snags			Total Live			Total		
(dbh)	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF
6	43.8	8.9	583	14.1	3.0	0	17.7	3.3	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	75.7	15.1	583	75.7	15.1	583
7	101.7	26.3	2,371	0.0	0.0	0	25.4	6.8	229	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	127.1	33.1	2,600	127.1	33.1	2,600
8	17.8	5.7	533	7.9	2.9	158	11.7	3.6	0	8.3	2.9	249	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	45.6	15.0	940	45.6	15.0	940
9	14.5	6.0	579	13.6	5.7	471	7.9	3.1	236	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	35.9	14.8	1,286	35.9	14.8	1,286
10	17.9	9.1	716	5.9	2.9	235	12.4	6.8	434	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	36.2	18.7	1,385	36.2	18.7	1,385
11	13.8	9.1	723	9.8	6.1	640	10.4	6.8	310	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	33.9	22.1	1,673	33.9	22.1	1,673
12	3.6	2.8	216	8.8	6.6	352	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	12.4	9.5	568	12.4	9.5	568
13	0.0	0.0	0	3.1	2.8	123	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	3.1	2.8	123	3.1	2.8	123
14	8.0	8.6	1,039	0.0	0.0	0	3.7	3.7	222	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	11.7	12.2	1,261	11.7	12.2	1,261
15	2.3	2.8	323	6.9	8.4	824	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	9.2	11.3	1,147	9.2	11.3	1,147
16	2.6	3.4	360	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	2.6	3.4	360	2.6	3.4	360
17	0.0	0.0	0	7.4	11.5	1,548	0.0	0.0	0	2.3	3.4	408	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	9.6	14.8	1,956	9.6	14.8	1,956
18	0.0	0.0	0	1.9	3.4	409	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	1.9	3.4	409	1.9	3.4	409
19	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0
20	0.0	0.0	0	1.3	2.8	298	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	1.3	2.8	298	1.3	2.8	298
21	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0
22	0.0	0.0	0	1.3	3.4	444	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	1.3	3.4	444	1.3	3.4	444
23	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0
24	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0
25	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0
26	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0
27	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0
28	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0
29	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0
30	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0
31	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0
32	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0
33	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0
Total	225.9	82.6	7,443	81.9	59.6	5,502	89.1	34.0	1,431	10.6	6.3	657	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	407.5	182.4	15,033	407.5	182.4	15,033

TPA = trees/acre
BA = basal area/acre (sq ft)
BF = board feet/acre

Data Collected: 11/2001

Appendix III. List of wildlife species potentially occurring on the 700 Road Forest Habitat Restoration Project Area, currently and in the future. Asterisks denote CRW-HCP species of concern.

			Habitat Association[1]									Habitat Elements[1]										
			Forest Stage						Aquatic													
Group	**Common Name**	**Scientific Name**	Open	Hardwood	Mixed	Young	Mature	Old-growth	Rivers, Streams	Wetlands/Riparian	Lakes, Ponds	Canopy Layers	Downed Wood	Snags	Tree Cavities	Hollow Trees	Large Branches	Mistletoe	Shrubs, Forbs, Grasses	Edges	Rocks/Talus	**other**
Invertebrates (incomplete list)																						
Insects	Carabid Beetle*	*Omus dejeanii*		X	X	X	X	X	X	X												
	Johnson's (Mistletoe) Hairstreak*	*Mitoura johnsoni*				X	X	X										X				
Mollusks	Blue-gray Taildropper*	*Prophysaon coeruleum*					X	X					X									moist
	Oregon Megomphix*	*Megomphix hemphilla*					X	X					X									
	Papillose Taildropper*	*Prophysaon dubium*					X	X		X			X								X	moist
	Puget Oregonian*	*Cryptomastix devia*		X			X	X		X			X								X	moist
Amphibians (8 species)																						
Salamanders	Northwestern Salamander*	*Ambystoma gracile*		X	X	X	X	X	X	X	X		X							X	X	
	Long-toed Salamander*	*Ambystoma macrodactylum*	X	X	X	X	X	X	X	X	X		X							X	X	
	Ensatina	*Ensatina eschscholtzii*	X	X	X	X	X	X					X	X								
	Western Redback Salamander*	*Plethodon vehiculum*	X	X	X	X	X	X					X								X	<3600'
	Roughskin Newt*	*Taricha granulosa*	X	X	X	X	X	X	X	X	X		X						X	X		
Frogs/Toads	Western Toad*	*Bufo boreas*	X	X	X	X	X	X	X	X	X		X									moist
	Pacific Treefrog	*Pseudacris regilla*	X	X	X	X	X	X	X	X	X											
	Northern Red-legged Frog*	*Rana aurora aurora*		X	X	X	X	X	X	X	X		X									
Reptiles (4 species)																						
Snakes	Rubber Boa	*Charina bottae*	X	X	X	X	X	X		X			X								X	burrows
	Western Terrestrial Garter Snake	*Thamnophis elegans*	X	X	X	X	X	X	X	X	X											burrows
	Northwestern Garter Snake	*Thamnophis ordinoides*	X	X	X	X	X	X														burrows
	Common Garter Snake	*Thamnophis sirtalis*	X	X	X	X	X	X	X	X	X								X			burrows
Birds (50 species)																						
Alcids	Marbled Murrelet*	*Brachyrhamphus marmoratus*					X	X									X	X				moss
Vultures	Turkey Vulture	*Cathartes aura*				X	X	X					X	X	X	X					X	cliffs, caves
Hawks	Sharp-shinned Hawk	*Accipiter striatus*			X	X	X			X		X								X		
	Cooper's Hawk	*Accipiter cooperii*		X	X	X	X	X		X		X								X		
	Northern Goshawk*	*Accipiter gentilis*		X	X		X	X		X			X	X				X	X	X		tree deformities
	Red-tailed Hawk	*Buteo jamaicensis*	X	X	X	X	X	X						X				X	X	X	X	cliffs
Falcons	American Kestrel	*Falco sparverius*	X		X	X	X	X						X	X					X	X	
Grouse/Quail	Blue Grouse	*Dendragapus obscurus*	X				X	X	X	X			X					X	X		X	springs
	Ruffed Grouse	*Bonasa umbellus*	X		X	X			X	X			X						X		X	springs
Owls	Western Screech Owl	*Otus kennicottii*		X	X	X	X	X		X				X	X							
	Great Horned Owl	*Bubo virginianus*	X	X	X	X	X	X						X	X	X		X		X	X	caves, cliffs
	Northern Pygmy Owl	*Glaucidium gnoma*		X	X	X	X	X						X	X							

			Habitat Association[1]									Habitat Elements[1]										
			Forest Stage						Aquatic													
Group	Common Name	Scientific Name	Open	Hardwood	Mixed	Young	Mature	Old-growth	Rivers, Streams	Wetlands/Riparian	Lakes, Ponds	Canopy Layers	Downed Wood	Snags	Tree Cavities	Hollow Trees	Large Branches	Mistletoe	Shrubs, Forbs, Grasses	Edges	Rocks/Talus	other
	Northern Spotted Owl*	*Strix occidentalis caurina*					X	X				X	X	X	X	X	X	X				flying squirrels
	Barred Owl	*Strix varia*				X	X	X	X	X				X	X	X		X				
	Northern Saw-whet Owl	*Aegolius acadicus*				X	X	X		X				X	X							
Swifts	Vaux's Swift*	*Chaetura vauxi*					X	X				X		X	X	X						insects
Woodpeckers	Red-breasted Sapsucker	*Sphyrapicus ruber*		X	X	X	X	X				X		X	X							
	Downy Woodpecker	*Picoides pubescens*		X	X	X	X	X				X		X	X							
	Hairy Woodpecker	*Picoides villosus*		X	X	X	X	X				X		X	X							
	Northern Flicker	*Colaptes auratus*		X	X	X	X	X						X	X	X				X		
	Pileated Woodpecker*	*Dryocopus pileatus*	X	X	X	X	X	X				X	X	X	X	X						insects
Flycatchers	Olive-sided Flycatcher*	*Contopus cooperi*	X	X	X	X	X	X		X		X		X						X		emergent trees
	Pacific-slope Flycatcher	*Empidonax difficilis*				X	X	X	X			X		X								
Corvids	Gray Jay	*Perisoreus canadensis*	X	X	X	X	X	X														
	Steller's Jay	*Cyanocitta stelleri*		X	X	X	X	X														
	American Crow	*Corvus brachyrhynchos*	X	X	X	X	X	X		X										X		
	Common Raven	*Corvus corax*					X	X													X	cliffs, caves
Tits/	Black-capped Chickadee	*Poecile atricapillus*	X	X	X	X	X	X				X	X	X	X				X	X		
Nuthatches/	Chestnut-backed Chickadee	*Poecile rufescens*		X	X	X	X	X				X		X	X							
Creepers	Mountain Chickadee	*Poecile gambeli*	X	X	X	X	X	X				X		X	X				X	X		
	Red-breasted Nuthatch	*Sitta canadensis*		X	X	X	X	X				X		X	X							bark
	Brown Creeper*	*Certhia americana*	X	X	X		X	X				X		X	X							moist, bark
Wrens	Winter Wren	*Troglodytes troglodytes*		X	X		X	X					X		X				X			moss, bark
Kinglets/	Golden-crowned Kinglet	*Regulus satrapa*		X	X		X	X				X										lichens
Thrushes	Townsend's Solitaire	*Myadestes townsendi*	X	X	X	X	X	X					X									
	Swainson's Thrush	*Catharus ustulatus*		X	X		X	X				X							X			moist conditions
	American Robin	*Turdus migratorius*	X	X	X	X	X	X												X		
	Hermit Thrush	*Catharus guttatus*	X	X	X		X	X											X			
	Varied Thrush	*Ixoreus naevius*		X	X	X	X	X											X			litter
Vireos	Cassins Vireo	*Vireo cassinii*		X	X			X				X										oak
	Warbling Vireo	*Vireo gilvus*		X	X			X		X		X							X	X	X	
	Red-eyed Vireo	*Vireo olivaceus*		X	X			X	X			X										
	Hutton's Vireo	*Vireo huttoni*		X	X			X		X		X							X	X		
Warblers	Townsend's Warbler	*Dendroica townsendi*		X	X	X	X	X				X										
Tanagers	Western Tanager	*Piranga ludoviciana*		X	X	X	X	X				X								X		
Sparrows	Dark-eyed Junco	*Junco hyemalis*	X	X	X		X	X					X						X	X		
Finches	Pine Siskin	*Carduelis pinus*		X	X	X	X	X				X							X			
	Purple Finch	*Carpodacus purpureus*	X	X	X		X	X				X							X			flowers

			Habitat Association[1]									Habitat Elements[1]										
			Forest Stage						Aquatic													
Group	**Common Name**	**Scientific Name**	Open	Hardwood	Mixed	Young	Mature	Old-growth	Rivers, Streams	Wetlands/Riparian	Lakes, Ponds	Canopy Layers	Downed Wood	Snags	Tree Cavities	Hollow Trees	Large Branches	Mistletoe	Shrubs, Forbs, Grasses	Edges	Rocks/Talus	**other**
	Red Crossbill	*Loxia curvirostra*					X	X				X							X			
	Evening Grosbeak	*Coccothraustes vespertinus*			X	X	X	X				X										
Mammals (42 species)																						
Bats	Big Brown Bat*	*Eptesicus fuscus*	X		X		X	X	X	X	X			X	X	X				X	X	bark, caves
	Silver-haired Bat*	*Lasionycteris noctivagans*					X	X	X	X	X			X	X	X					X	bark, caves
	Hoary Bat*	*Lasiurus cinereus*	X	X	X		X	X	X	X	X	X		X					X	X		caves
	Townsend's Big-eared Bat*	*Plecotus townsendii*	X				X	X	X	X	X	X				X				X		caves
	California Myotis*	*Myotis californicus*		X			X	X			X			X	X	X					X	bark, caves
	Long-eared Myotis*	*Myotis evotis*		X	X		X	X			X			X					X		X	bark, caves
	Keen's Myotis*	*Myotis keenii*					X	X			X			X	X	X				X	X	caves
	Little Brown Myotis*	*Myotis lucifugus*					X	X			X			X	X	X				X	X	bark, caves
	Fringed Myotis*	*Myotis thysanodes*	X				X	X			X			X	X	X				X	X	bark, caves
	Yuma Myotis*	*Myotis yumanensis*	X	X	X		X	X		X	X			X	X	X				X	X	bark, caves
	Long-legged Myotis*	*Myotis volans*	X	X	X		X	X			X			X	X	X				X	X	bark, caves
Shrews	Masked Shrew*	*Sorex cinereus*		X	X	X	X	X		X			X						X			moist, litter, burrows
	Montane Shrew	*Sorex monticolus*	X	X	X	X	X	X		X			X						X			litter, fungi, burrows
	Vagrant Shrew	*Sorex vagrans*	X	X	X	X	X	X	X	X									X			litter
	Trowbridge's Shrew	*Sorex trowbridgii*		X	X	X	X	X					X									fungi, burrows, litter
Moles	Shrew-mole	*Neurotrichus gibsii*	X	X	X	X	X	X	X				X									litter, burrows
	Coast Mole	*Scapanus orarius*	X				X	X					X						X			litter, burrows
Rats/Mice	Bushy-tailed Woodrat	*Neotoma cinerea*	X				X	X					X	X	X	X		X	X		X	fungi, caves, cliffs
	Deer Mouse	*Peromyscus maniculatus*	X	X	X	X							X						X	X		fungi, bark, litter, burrows
	Keen's Deer Mouse	*Peromyscus keeni*					X	X					X									
	Southern Red-backed Vole	*Clethrionomys gapperi*		X			X	X					X						X			fungi, litter, lichens
	Heather Vole	*Phenacomys intermedius*	X	X	X	X				X		X							X			burrows
	Pacific Jumping Mouse	*Zapus trinotatus*	X			X				X		X	X						X	X		fungi, burrows
Squirrels	Cascade Golden-mantled Ground Squirrel	*Spermophilus saturatus*	X	X	X	X	X	X					X								X	burrows, open forest
	Douglas' Squirrel	*Tamiasciurus douglasii*					X	X				X	X				X		X	X		fungi
	Northern Flying Squirrel	*Glaucomys sabrinus*					X	X					X	X	X	X	X	X				fungi, litter, moss
Mtn Beavers	Mountain Beaver	*Aplodontia rufa*		X	X	X	X	X					X						X			burrows, deep moist soil
Porcupines	Porcupine	*Erethizon dorsatum*	X			X	X	X					X			X			X	X	X	
Bear	Black Bear	*Ursus americanus*	X	X	X		X	X					X	X		X			X	X	X	tubers, bark, caves
Procyonids	Raccoon	*Procyon lotor*	X	X	X	X	X	X	X	X			X	X	X	X			X		X	burrows
Mustelids	Marten*	*Martes americana*					X	X	X	X		X	X	X	X		X	X	X		X	burrows, stumps
	Fisher*	*Martes pennanti*					X	X		X			X	X	X	X	X	X	X			cliffs, stumps
	Short-tailed Weasel (Ermine)	*Mustela erminea*		X	X	X	X	X		X			X								X	burrows

			Habitat Association[1]									Habitat Elements[1]										
			Forest Stage						Aquatic												
Group	**Common Name**	**Scientific Name**	Open	Hardwood	Mixed	Young	Mature	Old-growth	Rivers, Streams	Wetlands/Riparian	Lakes, Ponds	Canopy Layers	Downed Wood	Snags	Tree Cavities	Hollow Trees	Large Branches	Mistletoe	Shrubs, Forbs, Grasses	Edges	Rocks/Talus	**other**
	Long-tailed Weasel	*Mustela frenata*	X	X	X	X	X	X		X			X	X	X						X	burrows
	Striped Skunk	*Mephitis mephitis*	X	X	X	X	X	X		X			X	X							X	bark, litter, burrows
	Spotted Skunk	*Spilogale gracilis*		X	X	X	X	X					X	X	X	X					X	tubers, litter, burrows, cliffs
Cats	Cougar	*Felis concolor*	X	X	X	X	X	X					X				X				X	cliffs
	Bobcat	*Lynx rufus*	X	X	X	X	X	X					X						X		X	cliffs, caves
Canids	Red Fox	*Vulpes vulpes*	X							X			X						X	X		burrows, berry-producing shrubs
	Coyote	*Canis latrans*	X	X	X	X	X	X		X									X			burrows, berry-producing shrubs
Deer/Bovids	Elk	*Cervus elaphus*	X	X	X		X	X		X			X						X	X		
	Black-tail Deer	*Odocoileus hemionus*	X	X	X		X	X		X			X						X	X		

[1]Source: Cedar River Watershed Habitat Conservation Plan (CRW-HCP), Johnson and O'Neil (2001), Christy and West (1993), CRMW staff professional judgement

APPENDIX IV
SNAG CREATION TECHNIQUES: EFFECTIVENESS AND COSTS

The information presented here is from a series of phone calls to wildlife biologists, researchers, and contract administrators on the state and national forests in Oregon and Washington. There have been a variety of snag creation projects in the PNW in the past 30 or so years, but very limited monitoring. The monitoring results presented here are often fairly preliminary though some are from more rigorous statistical designs. The trends, however, are informative and help suggest considerations and likely results of snag creation projects.

Penny Harris and Ruby Seitz on the McKenzie River RD (Willamette NF) have done an exceptional job of monitoring their snag creation projects. Their data is compiled in Table 1, which compares the effectiveness and temporal scale of different techniques. Their bottom line recommendation is to use a variety of methods to create diverse and sustainable snag habitat. Snag use appears somewhat dependent on treatment type. Blasted and sawtopped trees provided the most opportunity for foraging *cavities* (penetrate the sapwood, but aren't large enough for nesting) while both girdling and inoculating showed a similar number of *holes* (do not penetrate the sapwood) as blasting. Sawtopping, though a very small sample size (n = 12, while the others were between 139 and 160), provided only foraging cavities, suggesting more accelerated decay than the other methods. As far as nesting cavities, blasting and sawtopping showed the greatest number of potential nest cavities. Potential nest cavities are beginning after about 10 years for both of these treatments.

Hallett et al. (2001) compared rates of mortality and decay between sawtopping and girdling. All treatments were done above the first whorl of branches at a height greater than 10m. They found that topped trees died faster but lasted longer as snags. Topped trees had cavities sooner (after 3 years in some cases) and had more conks and forage activity than girdled trees. In several cases the girdled trees appeared to heal over. This work as well as that of Harris and Seitz suggests that after treated trees die, they appear to be progressing through the typical snag decay classes, but rate of progression through decay classes is influenced by treatment type.

A monitoring review by the Mount Baker RD compared mortality and use among blasted, swatopped, and girdled trees. Blasted trees may be progressing a bit faster than girdled trees but there was no difference in mortality between sawtopped and blasted trees.

Similar to the McKenzie River RD, the Mount Baker RD did find that number of limbs remaining had a significant influence on mortality. As shown in Figure 1, trees that had more than 10 limbs remaining had a less than 40% chance of dying. Trees were monitored in 1998 but snags were created between 1985 and 1995. Most snags were 5 years old or less. It is likely that the results of this study are somewhat confounded by time since treatment since it is not clear that all treatments were done in all years.

Snag Creation Method	Natural disturbances simulated	Tree mortality	Advanced decay	Foraging use	Nesting use	Fall down rate
Topping with 4 live limbs left	wind breakage, lightning	1-3 years		2-4 years after mortality	8-12 years after mortality	*beginning 20-25 years after mortality*
high girdling with 4 live limbs left	beetle infestation, defoliators, frost damage	4-8 years		1-2 years after mortality	8-12 years after mortality	*beginning 20-25 years after mortality*
Inoculation with stem decays	stem decays	does not kill tree	*8-10 years*	Incidental	*20-30 years after inoculation*	same as any green tree
Inoculation with stem decays and sawtopping/girdling with 4 live limbs left	wind breakage, lightning strikes in trees with stem decay, hollow trees, frost damage	1-8 years	*3-5 years*	2-4 years after mortality	8-10 years after mortality	*beginning 20-30 years after mortality*
Inoculation with stem decays and sawtopping/girdling with >4 live limbs left	wind breakage, lightning strikes in trees with stem decay, hollow trees, frost damage	*30-35 years*	*3-8 years*	1-2 years after mortality	8-10 years after mortality	*40-60 years or more after treatment*

Table 1: one year of snag creation monitoring data about 8 years after the oldest treatment. Data from Penny Harris and Ruby Seitz, McKenzie River Ranger District, Willamette National Forest. Text in *italics* denotes hypothesized results not yet observed.

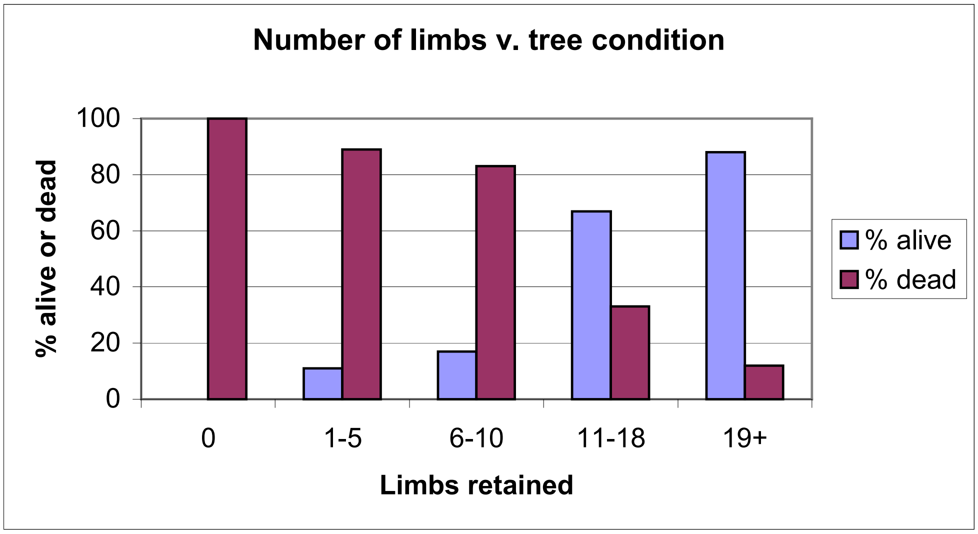


Figure 1: Number of limbs retained in relation to the percent of trees alive or dead 3 or more years after treatment. Data from Gay, 1998.

Don Gay, wildlife biologist on the Mount Baker RD, suggested that we also include natural snag creation in our list of options. Leaving clumps of trees to allow competitive exclusion to exist will create snags that we know will serve as good habitat.

Catherine Parks at the PNW LaGrande Research Station is the current lead on much of the work with heart rot inoculation. Next year she will be doing a lot of monitoring on her recent work. So far she has been using inoculum in operational Forest Service field trials. At this point, they can not supply it to anyone else. She does have a paper almost ready for publication that describes her procedure for growing out inoculum (and she would be willing to share that with us if we want). She suggested that Paul Stamets (in the mushroom growing business in Shelton) may have the lab and equipment required to contract out the growing. She did some work with the Darrington RD, who is planning to monitor and dissect some trees this year to examine effectiveness of inoculation.

Rayonier Timber Inc. has a study on their land in conjunction with a researcher from Arkansas State. Their initial results (Huss et al. 2002) suggest that inoculation was successful in introducing the fungal species to the tree. In conversations with Dan Varland (wildlife biologist for Rayonier) he said that six years post-treatment they are beginning to see conks on treated western hemlocks (near the inoculation hole) but not in Douglas fir.

ECONOMICS

Table 2 provides numbers from projects administered by Penny Harris on the McKenzie River RD (*Harris*) and from a publication by Jeff Lewis of Washington Department of Fish and Wildlife that collected data from contracts (*Lewis 1*) and interviews with contractors (*Lewis 2*). Costs on the McKenzie River contracts included treatment and data collection by the contractor.

This data consisted of tree species, dbh, height at treatment, treatment, number of live limbs below treatment, insect and wildlife use, and if inoculated, fungi species and aspect of PVC pipes.

Treatment Type	**Cost per tree**		
	Harris	*Lewis 1*	*Lewis 2*
Sawtopping	$38	$35	$37
Girdling	$30	$27.50	$19.50
Topping with blasting		$47.50	$44
Fungal inoculation	$40	$24	$33
Sawtopping and inoculating with 3 dowels above the 6th live limb	$46		
Sawtopping and inoculating with 2 dowels at 50% of the live crown	$46		
Girdling and inoculating with 3 dowels above the 6th live limb	$37		
Cavity creation		$34	$51
Cavity creation after blasting/sawtopping		$15	$17.50
Limbing		$32	$32

Table 2: Costs per tree of various snag creation treatments. *Harris* is data from contracts let on the McKenzie River RD. *Lewis 1* are values collected by Jeff Lewis from contracts throughout Washington stated. *Lewis 2*are values collected from contractors in the same study.

In the Harris data, the inoculum cost an additional $8-$9 per dowel, so three dowels would add an additional $24-$27/tree. With all the treatments there is an economy of scale such that the price per tree goes down as the contract involves more trees. In general, the Forest Service did snag creation work about 10 years ago and hasn't done much since. There are a few contracts going out now, and gradually people are trying more creative methods.

There are contradictory evaluations of the costs of sawtopping v. blasting. One biologist found sawtopping more expensive because it involved an individual actually climbing a tree with a chainsaw. In this case, blasting was done by hoisting explosives to the top of the tree and did not involve climbing. In contrast, others felt that blasting was more dangerous and therefore more expensive.

Topping and cavity creation was done in the CRMW in the early 1990's. Dwayne has some information about this. His sense is that most of the trees eventually blew down, as they were in very exposed areas (clearcuts). The cost was also much higher, and based on both his estimates and those of Sonny Paz (wildlife biologist for the North Bend RD who administered some of the snag creation in the watershed at the time) the range was between $300 and $600 per tree. The contractor (Tim Brown) is considered by himself and some within the agencies as an expert in snag creation techniques. Dwayne felt he took longer than necessary on the work and he may charge significantly higher rates than other contractors.

General Recommendations

1. Maintain existing snag structure
2. Leave dense patches of existing trees either around snags or so that snags will be formed naturally by competitive exclusion
3. Use a variety of techniques, species, and size classes and monitor results

Currently, there are several tested techniques, each providing a different rate of tree mortality. In a project like the 700 Road it may make sense to use multiple techniques, yielding snags at different points through time, rather than using a single technique which would kill all the trees at roughly the same time. Varying treated tree size and species will also expand the timeframe over which snags will be created.

The variable rate of decay and mortality from each technique goes hand in hand with the type of habitat each ultimately creates. Some techniques may not result in nesting habitat (for example, rot in hemlock may progress so fast that the tree falls before it can be used for nesting or removing all live limbs would kill a tree before rot can develop). But these techniques may still prove useful for forage. We don't really have enough long-term data to evaluate the progression of treated trees from forage providers to nesting providers. Current research interests (e.g., those of Andy Carey) seem to be exploring the balance between killing a tree before it can provide nesting habitat and having to wait 30 years before the tree provides any kind of habitat. This may involve techniques such as varying the numbers of branches left in conjunction with using heart rot inoculum.

It is important to identify what type of habitat is being targeted with the treatments, as different treatments and species of fungal inoculums will decay trees differently. Mechanical treatments alone (e.g., girdling or topping) will allow decay to establish first in the sapwood, providing foraging habitat. Using heartrot inoculum either alone or in conjunction with one of the mechanical treatments will accelerate decay from the inside.

Contacts

Phyllis Reed – MBS Darrington RD: 360-436-1155 x216
Wildlife biologist. Involved in some inoculation monitoring and they are planning to dissect some trees this year to examine the results (about 5 years post-treatment).

Dan Varland – Rayonier: 360-538-4582
Wildlife biologist for Rayonier, oversaw inoculation experiment on their lands in collaboration with researchers from Arkansas State University.

Penny Harris – WNF McKenzie River RD: 541-822-7265

Ruby Seitz – WNF McKenzie River RD: 541-822-7256
Penny and Ruby both have worked to do a lot of monitoring and some analysis of their results on their past 8+ years of snag creation work. Also have good cost figures.

Catherine Parks – LaGrande RD: 541-962-6531
Involved in the majority of inoculation studies throughout the region.

Kim Mellon – wildlife ecologist at the Regional Office: 503-808-2677

Has been trying to compile information on monitoring from the various projects throughout the region. Involved in creating DecAid.

Dale Oberlag – MBS Skykomish RD: 360-677-2414 x638

Wildlife biologist. Somewhat new to the district, but has access to contracts from the last 2-4 years and may be flying a contract this year as well.

Andy Carey – PNW Research Station Olympia: 360-753-7688

Done a variety of snag and cavity creation research in the PNW and places east for many years.

OTHER RESOURCES

Bull, E.L., C.G. Parks, and T.R. Torgersen. 1997. Trees and logs important to wildlife in the interior Columbia River Basin. USDA Forest Service general technical report PSW-GTR-391.

Gay, D. 1998. Results of 1998 KV wildlife tree monitoring program (pilot year). Unpublished report.

Hallett, J.G., T. Lopez, MA. O'Connell, and M.A. Borysewicz. 2001. Decay dynamics and avian use of artificially created snags. Northwest Science 75(4): 378-386.

Huss, M.J., J.C. Bednarz, D.M. Juliano, and D.E. Varland. 2002. The efficacy of inoculating fungi into conifer trees to promote cavity excavation by woodpeckers in managed forests in western Washington. USDA Forest Service general technical report PSW-GTR-181.

Harris, P.J., R. Seitz. 2002. Four dimensional snag creation and monitoring. A power point presentation showing results for the first year of monitoring after a variety of snag creation treatments over an 8 year time span.

Lewis, J.C. 1998. Creating snags and wildlife trees in commercial forest landscapes. Western Journal of Applied Forestry, 13(3): 97-101.

Local contractors providing professional snag and wildlife tree creation services (January 1997). From Jeff Lewis

Gray Owl Services Inc. (contact: Steve Dibiase) Seattle, 206-919-0873
Seattle Tree Service (contact: Mike Stanton) Lynnwood, 206-542-0286
Forest Sampling Systems (contact: Mike Ardington) Olympia, 360-956-3448

APPENDIX V
INDIVIDUAL MARKING/HARVEST GUIDES BY UNIT FOR 700 ROAD FOREST HABITAT RESTORATION PROJECT

UNIT E1 TARGET STAND PRESCRIPTION

Live Trees
- No trees may be cut exceeding the following diameter limits: (All larger trees are reserve trees)
  - Western hemlock: 19 inches
  - Douglas-fir: 19 inches
  - Western red cedar: 7 through 9 inches and 18 inches
- The harvest pool consists of these three species at or below the diameter limits. No other tree species may be harvested (these are also reserve trees).
- Approximately 137 live trees per acre will be cut across all diameters from within the harvest pool and removed from the unit. This amounts to a spacing of about 18 feet plus or minus 4 feet per tree. Note this spacing is to be used as if the reserve trees were not present - do not space off of reserve trees. Four snags per acre will be created from within the harvest pool to bring the effective removal of live trees to 141 trees per acre (see snag discussion below).
- Residual live trees per acre: 178 per acre
  - Approximately 82 non-target trees (reserve trees)
  - Approximately 96 live trees from the harvest pool
- Residual basal area per acre: 232 ft^2
- Residual relative density: 59
- Trees within the harvest pool with apparent damage (such as broken top, forked top, crook), signs of rot, or mistletoe brooms should be left unharvested, if at all possible.

Streams
- There are two streams that flow through this unit. One is just east of Road 700a and the other is about 1.27 miles east on the 700 from the junction of the 300/700 roads.
- No trees may be cut if their drip line falls within the bankfull width of the channel or any associated wetland or seep.
- Any trees cut near the stream channel will be felled away from the stream.
- No trees will be yarded through the stream channel unless there will be no disturbance either to the ground or the residual canopy.
- Large woody debris (LWD) enhancement
  - One tree will be felled across the stream channel about every 100 feet.
  - Source LWD trees will be from the harvest pool of Douglas-fir and western hemlock, 15-19 inches dbh.
  - Source LWD trees should not be selected if they are within the drip line of the channel.
  - Source LWD trees should be within 30 feet of the channel edge.

  - Should the top and/or the butt portion of the LWD tree interfere with yarding, that portion no closer than ten feet outside the bankfull width of the channel may be bucked and yarded as part of the sale.
- The eastern stream splits into two channels just below the 700 road. The above restrictions apply to both of these stream channels.

Snags

- Live trees for snag creation:
  - Four live trees per acre between the diameter limits of 15 and 19 inches for Douglas-fir and western hemlock and 15 to 17 inches for western red cedar will be selected for conversion to snags.
  - Tree species will be selected in the proportion in which they occur within this unit.
  - Live trees selected for conversion to snags will not be felled or treated during logging operations.
  - No live trees shall be selected for snags that are within 1 and ½ times the expected height of the snag to an active road.
  - Trees selected for conversion to snags shall be clumped rather than scattered across the unit, as much as possible, however no more than 20 trees may be clumped representing 5 acres worth.
  - Live trees selected for snags will be painted with yellow paint on two sides of the tree with a large letter S (large is 12 inches in length and 1 inch wide) by the fellers and/or the feller-buncher/processor operator.
- No existing snags shall be cut unless necessary for safety. If any snags need to be cut for safety, consider high stumping to at least 16 feet. Any snag cut or topped for safety will remain on site where felled.
- Any existing snags found which are >30 inches in diameter, and >30 feet in height will be left and buffered pending notification of the Contract Administrator, who will do a ground review and make a decision about whether or not to keep and buffer the snag.

Down Wood

- No existing down wood shall be removed from the site.
- If down wood <30 inches in diameter is interfering with operations, the part that is interfering may be bucked and pushed out of the way.
- If larger existing down wood (≥30 inches in diameter) is encountered, contact the Contract Administrator, who will do a ground review and made a decision about bucking and moving it.

UNITS E1 AND E2 GAPS AND SKIPS LAYOUT AND MARKING GUIDELINE

Note: The Gaps and Skips located in units E1, E2, and E8 have been marked. The following guide represents information for the Contractor on how gaps and skips were selected and marked on the ground.

Location, Marking, And Tree Selection Guideline

The following road distances are from the junction of the 300 and 700 roads. Use the vehicle odometer (in 1/10 mile increments) to estimate the distances. Exact placement is not required. The distance into the unit is an estimate based on traveling at a right angle from the road. Take a compass bearing from the road and follow it until you reach the desired distance.

Road and Foot Travel Distances for Gaps and Skips

Gap/Skip Number	Unit	Road Distance (in miles)	Road #	Distance Into Gap/Skip	Gap/Skip Circle Size (ac)
G1	E1	.12	700A	211	¼
S1	E1	.16	700A	131	¼
G2	E1	.29	700	206	½
S2	E1	.34	700A	338	½
G3	**E1**	**.46**	**700**	**380**	**½**
S3	E1	.53	700	290	½
G4	E1	.78	700	329	¼
S4	E1	.82	700	316	¼
B. G5	**E1**	**1.08**	**700**	**292**	**¼**
S5	**E1**	**1.13**	**700**	**422**	**¼**
G6	E1	1.39	700	373	¾
S6	E1	1.45	700	431	¾
G7	E2	.24	700	370	¼
S7	E2	.29	700	467	¼
G8	E2	.31	300	378	½
S8	E2	.35	300	450	½
G9	E2	.37	700	403	¾
S9	E2	.45	700	508	¾
G10	E2	.61	700	258	¼
S10	E2	.65	700	301	¼
G11	E2	.61	700	703	½
S11	E2	.64	700	755	½
G12	E2	.52	300	240	½
S12	E2	.56	300	197	½

The approximate plot center is at the designated distance and bearing from the road. At this point select the closest tree and make it the plot center. Put the appropriate tagging and flagging so that it will be easily visible from the outside edge of the gap or skip. One person will remain at plot center and use the laser rangefinder to direct the second person at the plot edge. The person at the edge will attach the appropriate tags. Enough line trees should be marked so that there is no question about the position of the line.

Skip and Gap Size

There will be three sizes of gaps and skips, ¼, ½, and ¾ acre.
Each skip and gap will be a circle in shape with the following radii:

¼	58.88
½	83.26
¾	101.98

Skip and Gap Placement

A SKIP **may be placed** over a stream channel. It is preferable to place skips around existing large snags and down wood. A GAP **may not** be closer than 50 feet to a stream. Use operational logistic considerations when placing the SKIP or Gap on the topography (i.e., leave sufficient space around the skip or gap so that logging equipment can maneuver around them).

Marking (all tagging is at eye level)

Marking Plot Center Tree

On four sides, using the reverse side of the Boundary Tags, staple two signs (one on top of the other) marked either with an S or G with the appropriate Gap or Skip number. These should be placed right next to each other. On the top and bottom of the marked Boundary tags staple a pink card in a horizontal position right next to the unit signs. Above these signs staple a series of three pink tags in a horizontal position separated by the width of the card on the same four sides as you placed the skip or gap signs.

Marking Gap and Skip Boundaries

Gap: On each line tree staple a double Boundary Sign using the reverse side. Place these reversed tags both on the inside of the Gap facing toward the plot center and on the opposite side of the tree facing away from plot center. Mark all tags with a G and appropriate gap number with a water-resistant felt tip pen. Be sure to use enough staples so that the tags will remain on the tree for several years. Enough line trees should be marked that there will be no question as to the plot boundary.

Skip: On each line tree of the skip instillation, place reversed Boundary Signs facing toward plot center using an S and the appropriate skip number. On the outside of the line tree staple a Boundary Sign with a pink flag on top and bottom.

Tree Selection Within the Gap

The following types and numbers of trees will be selected within the gaps

Gap Size	Live Trees Left	Trees For Snag Creation	Trees for DW Creation
¼ acre	0	0	0
½	2	2	2
¾	3	3	3

Live Tree Selection ***L***

These trees are to represent the largest trees within the gap. They should represent the conifer tree species generally found within the stand. As an example Douglas-fir would be the choice in a western hemlock/Douglas-fir stand. If one of the largest trees happens to be a multi-top large limb tree (wolf-tree type), this may be considered along with the other trees. Do not select a smaller (wolf tree) tree in favor of a larger sound dominant. There is no need to measure for the largest trees – visual estimates are sufficient. Live trees should be selected without regard to where they lay within the gap. If the three best trees are clumped, mark them anyway.

NOTE: Since all deciduous trees will be left within the matrix, they will not be selected as a live leave tree within the gap.

Live trees should be painted with orange paint on two sides with a large letter **L**. One side facing the plot center, the other on the opposite side.

Live Tree for Snag Conversion ***S***

The selection for these trees should be from the largest dominant trees (don't spend time measuring diameters) after the Live Leave trees have been selected. Deciduous trees may be considered in the selection for live trees to be converted to snags. They must be in the largest tree mix to be considered. A species mix is preferable if they exist as part of the largest trees. When selecting the trees to be converted, be sure that they can be climbed safely.

Trees for snag conversion should be painted with orange paint on two sides with a large letter **S**.

Live Trees for Down Wood ***D***

These will normally be the last trees you select. These again will be selected from the largest live trees (visual estimate). They may be of any species, with a mixture of species preferable. The selection of these trees should generally be from the edge of the gap, to ensure the maximum amount of wood on the ground as possible. The portion that falls outside of the gap is available for removal. Try to select the trees so they will parallel each other when they are felled. If, however, the best selection will cross each other when felled, this is acceptable. We will buck at the crossing so that the trees lay on the ground, providing more rapid decomposition.

Trees for down wood conversion should be painted with orange paint on two sides with a large letter **D**.

UNIT E2 TARGET STAND PRESCRIPTION

Live Trees

- No trees may be cut exceeding the following diameter limits: (All larger trees are reserve trees)
  - Western hemlock: 15 inches
  - Douglas-fir: 17 inches
  - Western red cedar: 15 inches
- The harvest pool consists of these three species at or below the diameter limits. No other tree species may be harvested (these are also reserve trees).
- Approximately 198 live trees per acre will be cut across all diameters from within the harvest pool and removed from the unit. This amounts to a spacing of about 15 feet plus or minus 3 feet. Note this spacing is to be used as if the reserve trees were not present - do not space off of reserve trees. Four snags per acre will be created from within the harvest pool to bring the effective removal of live trees to 202 trees per acre (see snag discussion below).
- Residual live trees per acre: 235
  - Approximately 80 non-target trees (reserve trees)
  - Approximately 156 trees from the harvest pool.
- Residual basal area per acre: 217 ft^2
- Residual relative density: 60
- Trees within the harvest pool with apparent damage (such as broken top, forked top, crook), signs of rot, or mistletoe brooms should be left unharvested, if at all possible.

Streams

- There are two streams that flow through this unit. One stream runs through the unit beginning at the junction of the 300/700 roads. The other is a continuation of the stream at the end of the road 700a.
- No trees may be cut if their drip line falls within the bankfull width of the channel.
- Trees cut near the stream will be felled away from the stream.
- No trees will be yarded through the stream channel unless there will be no disturbance either to the ground or the residual canopy.
- Large woody debris (LWD) enhancement
  - One tree will be felled across the stream channel about every 100 feet.
  - Source LWD trees will be from the harvest pool: Douglas-fir 14 to 17 inches, western hemlock 14 and 15 inches, and western red cedar 14 and 15 inches.
  - Source LWD trees should not be selected if they are within the drip line of the channel.
  - Source LWD trees should be within 30 feet of the channel edge.
  - Should the top and/or the butt portion of the LWD tree interfere with yarding, that portion no closer than ten feet outside the bankfull width of the channel may be bucked and yarded as part of the sale.

Snags

- Live trees for snag creation:

    - Four live trees per acre between the diameter limits of 14 and 15 inches for western hemlock and western red cedar and 14 through 17 inches for Douglas-fir within the harvest pool will be selected for conversion to snags.
    - Tree species will be selected in the proportion in which they occur within this unit.
    - Live trees selected for conversion to snags will not be felled or treated during logging operations.
    - No live trees shall be selected for snags that are within 1 and ½ times the expected height of the snag to an active road.
    - Trees selected for conversion to snags shall be clumped rather than scattered across the unit, as much as possible, however no more than 20 trees may be clumped representing five acres worth in any one location.
    - Live trees selected for snags will be painted with yellow paint on two sides of the tree with a large letter S (large is 12 inches in length and 1 inch wide) by the fellers and/or the feller/buncher or processor operator.
- No existing snags shall be cut unless necessary for safety. If any snags need to be cut for safety, consider high stumping to at least 16 feet. Any snag cut or topped for safety will remain on site where felled.
- Any existing snags found which are >30 inches in diameter, and >30 feet in height will be left and buffered pending notification of the Contract Administrator, who will do a ground review and make a decision about whether or not to keep and buffer the snag.

Down Wood
- No existing down wood shall be removed from the site.
- If down wood <30 inches in diameter is interfering with operations, the part that is interfering may be bucked and pushed out of the way.
- If larger existing down wood (≥30 inches in diameter) is encountered, contact the Contract Administrator, who will do a ground review and made a decision about bucking and moving it.

UNIT E3 TARGET STAND PRESCRIPTION

Live Trees

- Trees are to be selected (for cutting and snag creation) from across all diameters of western hemlock, Douglas-fir, western red cedar, and Pacific silver fir.
- *Only those trees ≤17 inches dbh may be cut and removed from the unit. The larger selected trees will be converted to snags* (see snag discussion below).
- 114 live trees per acre will be cut from trees <17 inches dbh and removed from the unit. This represents a spacing of about 19 feet plus or minus 4 feet for variability. Twelve snags per acre will be created from larger trees to bring the effective removal of live trees to 125 trees per acre (see snag discussion below).
- Residual live trees per acre: 281
- Residual basal area per acre: 192 ft^2
- Residual relative density: 57
- Trees within the harvest pool with apparent damage (such as broken top, forked top, crook), signs of rot, or mistletoe brooms should be left unharvested, if at all possible.

Snags

- Live trees for snag creation:
  - Twelve live trees per acre will be selected from all species with diameters greater than 14 inches.
  - Tree species will be selected in the proportion in which they occur within this unit.
  - These selected live trees may be clumped where possible so long as the diameter qualifications are met, however no more than 20 trees may be clumped.
  - Live trees selected for conversion to snags will not be felled or treated during logging operations.
  - No live trees shall be selected for snags that are within 1 and ½ times the expected height of the snag to an active road.
  - These trees will be marked with a large letter S (12 inches tall and 1 inch thick) in yellow paint on two sides of the selected tree by the contractor either prior to cutting or during cutting.
- No existing snags shall be cut unless necessary for safety. If any snags need to be cut for safety, consider high stumping to at least 16 feet. Any snag cut or topped for safety will remain on site where felled.
- Any snags found which are >30 inches in diameter, and >30 feet in height will be left and buffered pending notification of the Contract Administrator, who will do a ground review and make a decision about whether or not to keep and buffer the snag.

Down Wood

- No existing down wood shall be removed from the site.
- If down wood <30 inches in diameter is interfering with operations, the part that is interfering may be bucked and pushed out of the way.
- If larger existing down wood (≥30 inches in diameter) is encountered, contact the Contract Administrator, who will do a ground review and made a decision about bucking and moving it.

UNIT E4 TARGET STAND PRESCRIPTION

Live Trees

- No trees may be cut exceeding the following diameter limits: (All larger trees are reserve trees)
  - Western hemlock: 13 inches
  - Douglas-fir: 15 inches
  - Western red cedar: 10 inches
- The harvest pool consists of these three species at or below the diameter limits. No other tree species may be harvested (these are also reserve trees).
- About 158 live trees per acre will be cut across all diameters from within the harvest pool and removed from the unit. This represents a spacing of about 17 feet plus or minus 4 feet for spacing variability and flexibility. This spacing is made as if the reserve trees were not present - do not space off of reserve trees. Four snags per acre will be created from within the harvest pool to bring the effective removal of live trees to 162 trees per acre (see snag discussion below).
- Residual live trees per acre: 252
  - Approximately 91 non-target trees (Reserve trees)
  - Approximately 161 trees from the harvest pool.
- Residual basal area per acre: 185 ft^2
- Relative density: 54
- Trees within the harvest pool with apparent damage (such as broken top, forked top, crook), signs of rot, or mistletoe brooms should be left unharvested, if at all possible.

Snags

- Live trees for snag creation:
  - Four live trees per acre between the diameter limits of 11 and 15 inches for Douglas-fir and 11-13 inches for western hemlock will be selected for conversion to snags.
  - Tree species will be selected in the proportion in which they occur within this unit.
  - Live trees selected for conversion to snags will not be felled or treated during logging operations.
  - No live trees shall be selected for snags that are within 1 and ½ times the expected height of the snag to an active road.
  - Trees selected for conversion to snags shall be clumped rather than scattered across the unit, as much as possible
  - These trees will be marked with a large letter S (12 inches tall and 1 inch thick) in yellow paint on two sides of the selected tree by the contractor either prior to cutting or during cutting.
- No existing snags shall be cut unless necessary for safety. If any snags need to be cut for safety, consider high stumping to at least 16 feet. Any snag cut or topped for safety will remain on site where felled.
- Any snags found which are >30 inches in diameter, and >30 feet in height will be left and buffered pending notification of the Contract Administrator, who will do a ground review and make a decision about whether or not to keep and buffer the snag.

Down Wood

- No existing down wood shall be removed from the site.
- If down wood <30 inches in diameter is interfering with operations, the part that is interfering may be bucked and pushed out of the way.
- If larger existing down wood (≥30 inches in diameter) is encountered, contact the Contract Administrator, who will do a ground review and made a decision about bucking and moving it.

UNIT E5 TARGET STAND PRESCRIPTION

Live Trees

- No trees may be cut exceeding the following diameter limits: (All larger trees are reserve trees)
  - Western hemlock: 11 inches
  - Douglas-fir: 19 inches
- The harvest pool consists of these two species at or below the diameter limits. No other tree species may be harvested (these are also reserve trees).
- Approximately 83 live trees per acre will be cut across all diameters from within the harvest pool and removed from the unit. This represents a spacing of about 27 feet with an allowance of plus or minus 5 feet for flexibility in selection. The spacing is made as if the reserve trees did not exist - do not space off of reserve trees. Four snags per acre will be created from within the harvest pool to bring the effective removal of live trees to 87 trees per acre (see snag discussion below).
- Residual live trees per acre:124
  - Approximately 64 non-target trees (Reserve trees)
  - Approximately 60 trees from the harvest pool.
- Residual basal area per acre:164 ft^2
- Residual relative density: 42
- Trees within the harvest pool with apparent damage (such as broken top, forked top, crook), signs of rot, or mistletoe brooms should be left unharvested, if at all possible.

Snags

- Live trees for snag creation:
  - Four live Douglas-fir trees per acre, between the diameter limits of 15 and 19 inches within the harvest pool will be selected for conversion to snags.
  - Tree species will be selected in the proportion in which they occur within this unit.
  - These trees may be clumped in-groups of no more than 20 trees representing five acres so long as the size limitation is adhered to. Scattered clumps are desirable, whenever possible.
  - Live trees selected for conversion to snags will not be felled or treated during logging operations.
  - No live trees shall be selected for snags that are within 1 and ½ times the expected height of the snag to an active road.
  - These trees will be marked with a large letter S (12 inches tall and 1 inch thick) in yellow paint on two sides of the selected tree by the contractor either prior to cutting or during cutting.
- No existing snags shall be cut unless necessary for safety. If any snags need to be cut for safety, consider high stumping to at least 16 feet. Any snag cut or topped for safety will remain on site where felled.
- Any existing snags found which are >30 inches in diameter, and >30 feet in height will be left and buffered pending notification of the Contract Administrator, who will do a ground review and make a decision about whether or not to keep and buffer the snag.

Down Wood

- No existing down wood shall be removed from the site.
- If down wood <30 inches in diameter is interfering with operations, the part that is interfering may be bucked and pushed out of the way.
- If larger existing down wood (≥30 inches in diameter) is encountered, contact the Contract Administrator, who will do a ground review and made a decision about bucking and moving it.

UNIT E6 TARGET STAND PRESCRIPTION

Live Trees

- No trees may be cut exceeding the following diameter limits: (All larger trees are reserve trees)
  - Western hemlock: 14 inches
  - Douglas-fir: 17 inches
  - Western red cedar: less than 11 inches and greater than 15 inches.
- The harvest pool consists of these three species at or below the diameter limits. No other tree species may be harvested (these are also reserve trees).
- About 209 live trees per acre will be cut across all diameters from within this harvest pool and removed from the unit. This represents a spacing of approximately 14 feet with a plus or minus 3 feet for variation in selection. This spacing is made as if the reserve trees did not exist - do not space off of reserve trees. Four snags per acre will be created from within the harvest pool to bring the effective removal of live trees to 213 trees per acre (see snag discussion below).
- Residual live trees per acre: 232
  - Approximately 93 non-target trees pre acre (Reserve trees)
  - Approximately 139 trees from the harvest pool.
- Residual basal area per acre: 208 ft^2
- Residual relative density: 58
- Trees within the harvest pool with apparent damage (such as broken top, forked top, crook), signs of rot, or mistletoe brooms should be left unharvested, if at all possible.

Streams

- There is one stream that approximately bisects the unit. There are overflow or secondary channels that have been flagged with white flagging and are also considered part of the stream channel.
- No trees may be cut if their drip line falls within the bankfull width of the channel.
- Trees cut adjacent to the full bank width of the stream will be felled away from the stream.
- No trees will be yarded through the stream channel unless there will be no disturbance either to the ground or the residual canopy.
- Large woody debris (LWD) enhancement
  - One tree will be felled across the stream channel about every 100 feet.
  - Source LWD trees will be from the harvest pool: Douglas-fir 14-17 inches, western hemlock 14 inches, and western red cedar 14 and 15 inches.
  - Source LWD trees should not be selected if they are within the drip line of the channel.
  - Source LWD trees should be within 30 feet of the channel edge.
  - Should the top and/or the butt portion of the LWD tree interfere with yarding, that portion no closer than ten feet outside the bankfull width of the channel may be bucked and yarded as part of the sale.

Snags

- Live trees for snag creation:

- Four live trees per acre will be selected from the harvest pool having the following diameters: western hemlock 14 inches, Douglas-fir 14 to 17 inches and western red cedar 14 to 15 inches.
- Tree species will be selected in the proportion in which they occur within this unit.
- The selected trees may be clumped in groups no larger than 20 trees so long as they meet the size criteria. Clumping is preferred to scattered.
- Live trees selected for conversion to snags will not be felled or treated during logging operations.
- No live trees shall be selected for snags that are within 1 and ½ times the expected height of the snag to an active road.
- These trees will be marked with a large letter S (12 inches tall and 1 inch thick) in yellow paint on two sides of the selected tree by the contractor either prior to cutting or during cutting.

* No existing snags shall be cut unless necessary for safety. If any snags need to be cut for safety, consider high stumping to at least 16 feet. Any snag cut or topped for safety will remain on site where felled.
* Any existing snags found which are >30 inches in diameter, and >30 feet in height will be left and buffered pending notification of the Contract Administrator, who will do a ground review and make a decision about whether or not to keep and buffer the snag.

Down Wood

- No existing down wood shall be removed from the site.
- If down wood <30 inches in diameter is interfering with operations, the part that is interfering may be bucked and pushed out of the way.
- If larger existing down wood (≥30 inches in diameter) is encountered, contact the Contract Administrator, who will do a ground review and made a decision about bucking and moving it.

UNIT E7 TARGET STAND PRESCRIPTION

- No trees may be cut exceeding the following diameter limits: (All larger trees are reserve trees)
  - Western hemlock: 10 inches
  - Douglas-fir: 10 inches
  - Western red cedar: 7 inches or less and greater than 12 inches
- The harvest pool consists of these three species at or below the diameter limits. No other tree species may be harvested (These are also reserve trees).
- Approximately 200 live trees per acre will be cut across all diameters from within the harvest pool and removed from the unit. This represents a spacing of about 15 feet with an additional plus or minus 3 feet for flexibility in selection. This spacing is made as if the reserve trees did not exist - do not space off of reserve trees. Four snags per acre will be created from within the harvest pool to bring the effective removal of live trees to 204 trees per acre (see snag discussion below).
- Residual live trees per acre: 235
  - Approximately 103 non-target trees pre acre (Reserve trees)
  - Approximately 132 trees from the harvest pool.
- Residual basal area per acre: 135 ft^2
- Residual relative density: 42
- Trees within the harvest pool with apparent damage (such as broken top, forked top, crook), signs of rot, or mistletoe brooms should be left unharvested, if at all possible.

Snags

- Live trees for snag creation:
  - Four live trees per acre between the diameter limits of 10 inches for western hemlock and Douglas-fir and 10 to 12 inches for western red cedar will be selected to be converted to snags.
  - Tree species will be selected in the proportion in which they occur within this unit.
  - These trees may be clumped up to 20 trees so long as they meet the size criteria, otherwise they may be scattered. Clumping is preferred.
  - Live trees selected for conversion to snags will not be felled or treated during logging operations.
  - No live trees shall be selected for snags that are within 1 and ½ times the expected height of the snag to an active road.
  - These trees will be marked with a large letter S (12 inches tall and 1 inch thick) in yellow paint on two sides of the selected tree by the contractor either prior to cutting or during cutting.
- No existing snags shall be cut unless necessary for safety. If any snags need to be cut for safety, consider high stumping to at least 16 feet. Any snag cut or topped for safety will remain on site where felled.
- Any existing snags found which are >30 inches in diameter, and >30 feet in height will be left and buffered pending notification of the Contract Administrator, who will do a ground review and make a decision about whether or not to keep and buffer the snag.

Down Wood

- No existing down wood shall be removed from the site.
- If down wood <30 inches in diameter is interfering with operations, the part that is interfering may be bucked and pushed out of the way.
- If larger existing down wood (≥30 inches in diameter) is encountered, contact the Contract Administrator, who will do a ground review and made a decision about bucking and moving it.

UNIT E8 TARGET STAND PRESCRIPTION

Live Trees

- No trees may be cut exceeding the following diameter limits: (All larger trees are reserve trees)
  - Western hemlock: 13 inches
  - Douglas-fir: 13 inches
- The harvest pool consists of these two species at or below the diameter limits. No other tree species may be harvested (These are also reserve trees).
- Approximately 223 live trees per acre will be cut. To achieve this level of cut, all western hemlock and Douglas-fir $\leq$ 12 inches, plus 43% of the 13 inch dbh western hemlock will be cut.
- Four snags per acre will be created from within the harvest pool to bring the effective removal of live trees to 227 trees per acre (see snag discussion below).
- Residual live trees per acre: 142
  - Approximately 114 non-target trees pre acre (Reserve trees)
  - Approximately 28 western hemlocks that are 13 inch dbh.
- Residual basal area per acre: 210 ft^2
- Residual relative density: 52
- Trees within the harvest pool with apparent damage (such as broken top, forked top, crook), signs of rot, or mistletoe brooms should be left unharvested, if at all possible.

Snags

- Live trees for snag creation:
  - Four live trees per acre of 13 inch dbh western hemlock and Douglas-fir will be selected to be converted to snags.
  - Tree species will be selected in the proportion in which they occur within this unit.
  - These trees may be clumped up to 20 trees so long as they meet the size criteria, otherwise they may be scattered. Clumping is preferred.
  - Live trees selected for conversion to snags will not be felled or treated during logging operations.
  - No live trees shall be selected for snags that are within 1 and ½ times the expected height of the snag to an active road.
  - These trees will be marked with a large letter S (12 inches tall and 1 inch thick) in yellow paint on two sides of the selected tree by the contractor either prior to cutting or during cutting.
- No existing snags shall be cut unless necessary for safety. If any snags need to be cut for safety, consider high stumping to at least 16 feet. Any snag cut or topped for safety will remain on site where felled.
- Any existing snags found which are >30 inches in diameter, and >30 feet in height will be left and buffered pending notification of the Contract Administrator, who will do a ground review and make a decision about whether or not to keep and buffer the snag.

Down Wood

- No existing down wood shall be removed from the site.

- If down wood <30 inches in diameter is interfering with operations, the part that is interfering may be bucked and pushed out of the way.
- If larger existing down wood ($\geq$30 inches in diameter) is encountered, contact the Contract Administrator, who will do a ground review and made a decision about bucking and moving it.

APPENDIX VI
CRMW ECOLOGICAL HARVEST ENGINEERING DESIGN: THE 700 ROAD FOREST HABITAT RESTORATION UNIT

700 Road Forest Habitat Restoration Unit

CRMW Ecological Harvest Engineering design: The 700 Road Forest Habitat Restoration Project

INTRODUCTION

Spring of 2003, Silvicultural Engineering visited the 700 Road Forest Habitat Restoration Project site and subsequently reviewed the draft site management plan including the ecological objectives silvicultural prescriptions, and provided comments on the cutting guidelines.

PROBLEM STATEMENT

In September 2003, Silvicultural Engineering was asked for expertise in harvest engineering design, with options—Settings—that address several constraints.

The constraints are:

1. No ground based machinery may cross a stream channel or travel within 30 feet of a stream.
2. All logs must be yarded away from streams.
3. Minimal ground disturbance over the entire project area.
4. Cable logging must have at least one-end suspension.
5. Skyline yarding must not damage live crowns of retained trees.
6. Live tops must not be broken and live crown ratios must not be reduced below 40%.
7. Minimal bark and root damage as described below;

> <u>Bark damage</u> -one or more scars on a trunk of a tree exposing the cambium layer more than 40 square inches;
>
> <u>Root damage</u> -a leave tree with more than 1/3 of the circumference of its root system injured such that the cambium layer is exposed.

Based on this direction, CRMW staff and Silvicultural Engineering worked together to develop the data for the harvest setting design process. A coordinated effort between the CRMW engineering, GIS, and ecology staff initiated this analysis. Amy Labarge and her staff prepared forest ecology and silvicultural prescriptions. Marti Spencer (CRMW), Silvicultural Engineering, and Pacific Forest Resources (Steve Faulkner) scoped prospective road reconstruction and landing placement.

The result of this effort detailed the harvest engineering idiosyncrasies of each of seven Ecological Thinning Units (ETU), plus one Restoration Thinning Unit (RTU). While there may be limitations in terms of the CRMW-qualified logging contractors, equipment specifications should not be an obstacle for implementing setting designs. Financial considerations are not ignored but these settings emphasize ecological restoration goals.

This document will provide City of Seattle staff and prospective logging contractors the information they need to propose specific logging systems. Proposals may be judged more fairly if the initial design criteria are made explicit. Variations from these designs are expected as contracts become finalized

METHODS

A. Forest engineering scenarios for ground based operations will be designated trails with roadside landings. Mechanized harvest is the preferred system because of the concern for site degradation.

B. Forest engineering for the steep slope settings includes four typical scenarios.

(1) A small mobile yarder (e.g. swing yarder) with intermediate supports to provide full suspension. Logs are yarded uphill and hauled on reconstructed road 311, east to the 310, onto the 300 mainline, and out of the watershed. These settings require several thousand feet of road reconstruction, landings, and some new road construction.

(2) A larger tower (e.g. TMY-70) set up to yard downhill on the 700 spur. A spar tree or mobile tower will be used along the ridge line with tailholds set up to 40 feet. Logs are hauled west on 700 spur to the 300 mainline. This option requires rough development of ridgeline access for tailholds.

(3) Helicopter yarding would land the logs directly onto the 700 mainline, at the western end of the planning area near the 300 rd Jct.. No road work will be required. Extensive landing development on existing road would be required to safely operate an airship and log loading facility simultaneously.

(4) A combination of a small tower (~70 foot tall) that will downhill yard the North and South faces of the ridge units (E-3,4.5.6 7) and helicopter for the remainder on the ridge top An expanded heli-landing would be designed for repeated use in developing future Ecological Thinning Units. This option avoids expensive road building along the ridge. Non-merchantable material will be slashed and left on site as per a contract (e.g. “slashed so all material lays on the ground”).

These scenarios, generally, increase incrementally in cost and complexity.

A design process made realistic comparisons between the feasibility of the skyline scenarios—Settings—based on a number of design elements (Berg and Schiess 1997). The first step is build PLANS (Twito et al. 1987). There are several steps to this that allow CRW-GIS data to be imported and analyzed.

A USGS format DEM is converted to a DTM

ARC covers (e.g. Roads, Streams, ETU boundaries) exported in an ungenerated format.

The line work (e.g. Roads, Streams, Unit boundaries) superimposed on DTM

Once built, a variety of skyline options can be compared based on the technical descriptions and solutions from PLANS. CRW can now design specific corridors in PLANS, field verify (and adjust GIS, based on field observations), and then suggest setting configurations to purchasers. The advantage being the reliability that ecological design elements are sufficiently reserved.

Detailed analysis in LoggerPC (OSU & USFS-PNW R-6) offers insight into the lateral pulling capabilities from these leads, often complicated by the introduction of intermediate supports. However, given the relatively small log size (e.g. 19 inch dbh), spacing of 150-200 feet between settings is not unreasonable (e.g. lateral yarding of 75-100 feet).

Ecological Setting Design

Design Issues on the 700 road

Silvicultural Design Element—Timber size

CRMW staff developed silvicultural prescriptions, designed to accelerate recovery of these forest stands to a late seral condition. A reasonable attempt must be made to estimate the expected payloads from these prescriptions. The equipment specified must be sufficient to fully suspend most of the logs.

(1) Estimate the distribution of log weights (from the inventory data and (e.g. Gholz, H.L. et al. 1979).
(2) Estimate target payload (~75% of Size distribution from above)
(3) Accumulate logs to achieve reasonable skyline or helicopter payloads

Payload analysis for skyline design requires plotting the distribution of logs by size (typically, DBH is used as a surrogate for size; (e.g. Gholz equations). This is accumulated from the inventory data by planning unit and species. A point is established (e.g. 75% point) where a specified yarder can easily suspend most of the logs. Inventory information allows a more reasoned estimate of target payload for equipment selection. The abundance of small diameter material (as per CRMW inventory data) to be removed seems to indicate that most payloads will be well below equipment technical design capability.

Equipment Design Elements

Yarders are picked from those that are available in the industry and are keyed to the target payloads, capability to safely operate, and technical specifications (e.g. maximum yarding distance, suspension requirements, and tower and tailhold anchoring requirements).

On the uphill yarding option, limitations on the equipment includes the lack of sufficient guy trees for large towers. Also, the ridge top terrain is such that long guy wires required for large towers (e.g. Skagit 090 90 foot tower) will not reach the slope if rigged properly at about 45^0 from the top of the tower.

For downhill yarding, presence of tall tail trees on the ridge top may limit the actual locations of yarding corridors. There appears to be sufficient anchor trees for tower settings along both the 700 and 300 roads.

Setting Design Elements

Feasible settings are proposed (PLANS, Local knowledge, best professional judgement). The setting locations are geographic information. The actual skyline roads are field verified; as DTM/DEM data accuracy is realistically only 80-90 percent. Tail trees and guy anchors are verified at this time as well.

Advances in laser imagery (LIDAR) give CRMW the opportunity to apply state of the art, landscape level imagery to the surface DEM. The details on the landform surface that LIDAR is detects are stunning (e.g. hidden roads, stream centerlines, geologic event remnants).

Ecological Design Elements **--** Structural Retention (STR) Design

Once feasible skyline settings are proposed structural retention (STR) can be super-imposed on the landscape. Questions will arise about the level and type of biological legacies that are retained.

Because the skylines are designed for full suspension and the forest is fairly young, consideration for log “flyways” –yarding roads—would simplify some of the uphill yarding options. Placement of STR will be within the guidelines provided for in the silvicultural prescriptions.

Cost

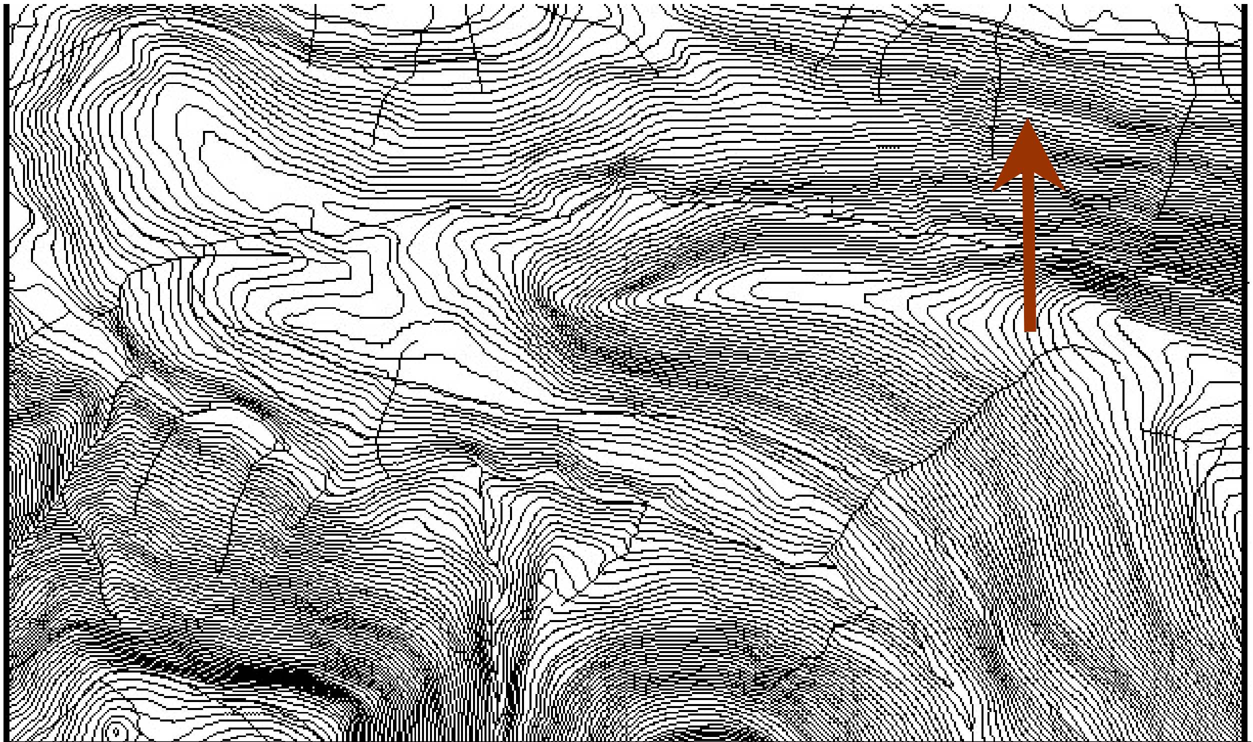
Detailed financial analysis requires information about the equipment, timber value, and amenity (e.g. ecological, aesthetic) value. All of these vary widely but some estimate must be made.

Ground based logging is limited to the mechanized processor-forwarder systems because of the soil disturbance constraints. Cost vary but range between $125-$150 per Mbf. These systems are limited to terrain of less than 35% slope.

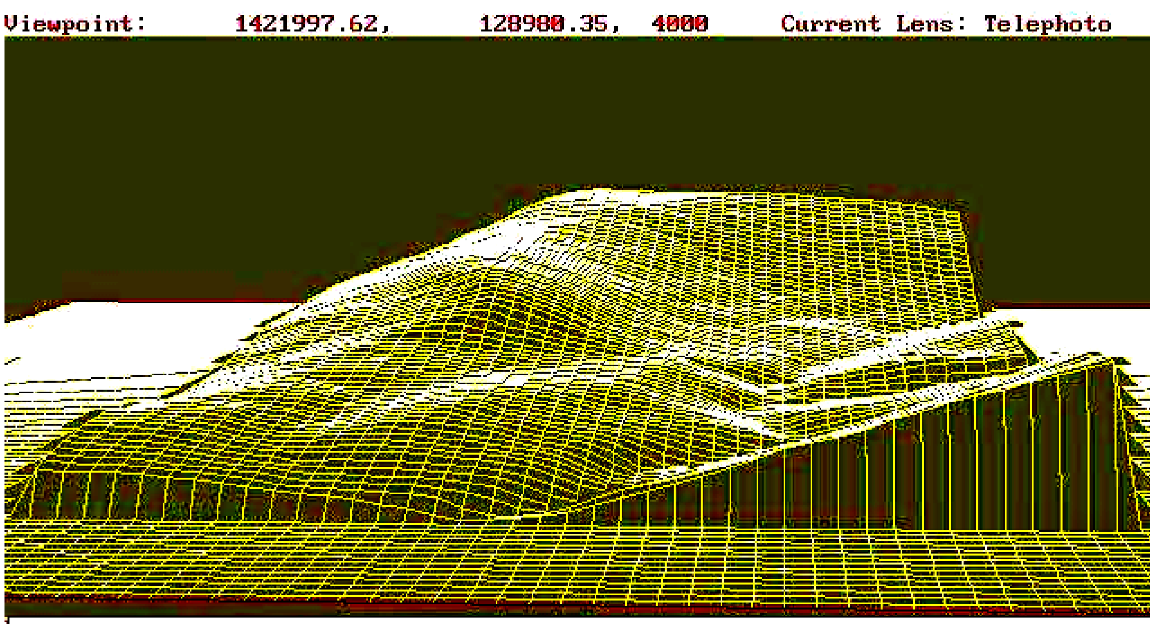
Here, both of the skyline options (between $165-$240 per Mbf), are less expensive than the helicopter option. The smaller tower with intermediate supports may be only slightly less than that of the larger machine used in the downhill yarding due mainly to the extra work setting up numerous intermediate supports.

While helicopter logging costs (in excess of $250-$300 per Mbf for a small ship) are high, there is a trade-off in the lower road building costs, which are limited to haul road and landing improvements.

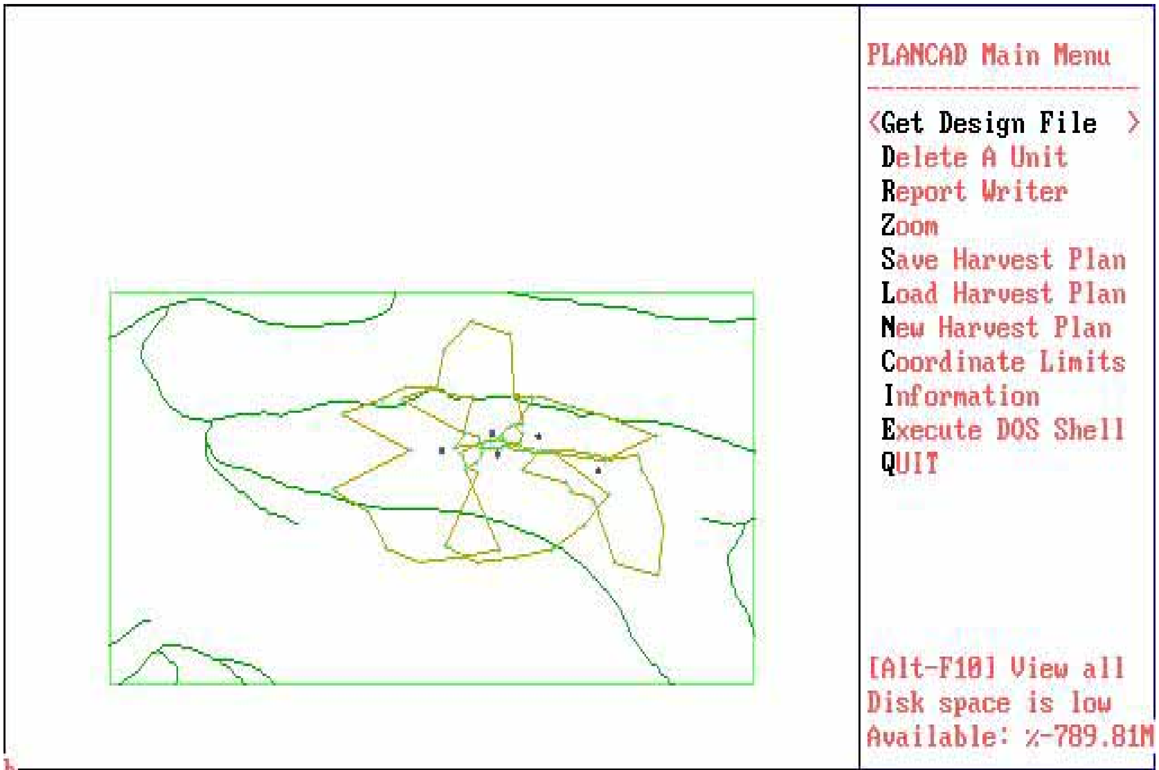
RESULTS



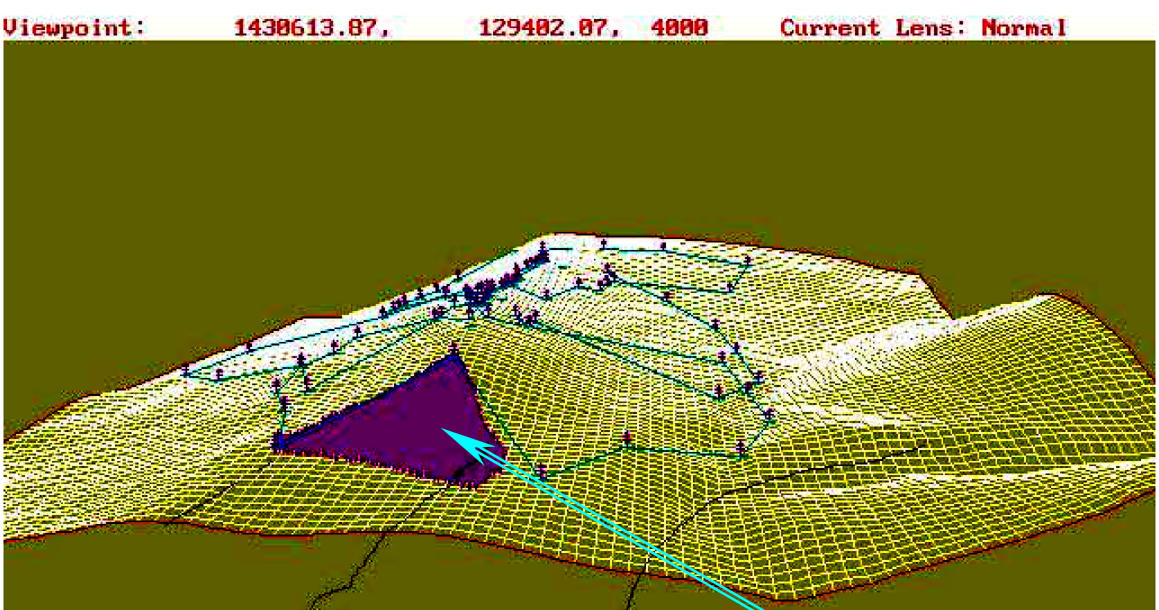
Geographic Extent of DTM with Streams and Roads from CRW-GIS



DEM data converted to DTM, viewed from the West, looking east over planning area.



Settings with tower locations to cover ridge in the middle-East portion of planning area.



A set of feasible skyline setting boundaries (design from PLANS) with a large reserve patch, aggregated structural retention, STR. STR is based on skipping several radial yarding roads. Individual tree STR may also designed along individual skyline locations. View if looking east at about 4000 feet elevation.

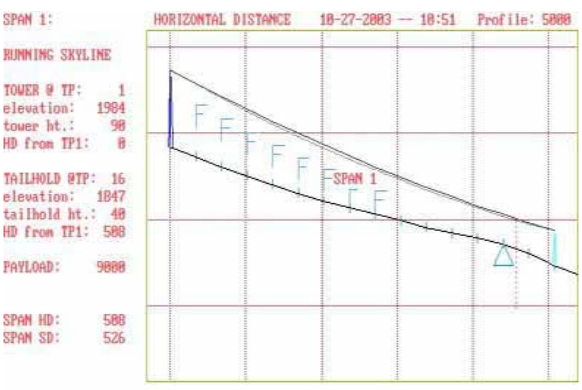
Ecological Thinning Unit E 1

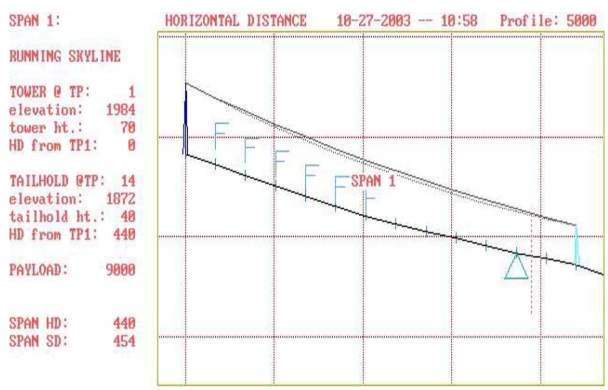
Ground Based

While the terrain barely meets the criteria on the western end of this unit, a system of parallel corridors placed such that logs can be forwarded west to the spur off of the 700 main line.

Skyline

Two stream crossings and steep slopes push the remainder of this unit towards some kind of light skyline configuration. Parallel yarding roads will be placed perpendicular to the mainline with the landings on the mainline. There appears to be sufficiently large trees and stumps to anchor tower guylines along the road. Sufficient tail trees exist in the riparian zone below to enable elevated tailholds (e.g. 40 foot high), improving deflection. Field location of skyline location will be necessary as STR gaps and skips have already been located on the ground.





Skylines can be smaller than designed because the probable payload will be less that the design payload of 9000 pounds. However, if deflection—minimal ground-lead—is a strong constraint then a larger machine would be recommended.

Also, these same settings may be used to log the adjacent units to the north (See Ecological Thinning Unit E 5 & 6 below).

Gaps will be best centered on yarding roads (for ease of yarding) because of the high level of STR in the remainder of the stand.

Helicopter

A small ship will yard these payloads easily to the main line. While expensive there will be minimal ground and residual tree damage.

Recommendations

1. Ground Based

A system of parallel corridors placed on the western end of this unit, such that logs can be forwarded west to the spur off of the 700 main line.

2. Skyline

Parallel yarding roads are placed perpendicular to the 700 mainline with landings on the mainline. There appears to be sufficiently large trees and stumps to anchor tower guylines along the road. Sufficient tail trees exist in the riparian zone below to enable elevated tailholds (e.g. 40 foot high), improving deflection. Field location of skyline location will be necessary as STR gaps and skips have already been located on the ground. Gaps are centered on yarding roads (for ease of yarding) because of the high level of STR.

Skylines can be smaller than designed (e.g. in PLANS) because the probable payload will be less that the design payload of 9000 pounds. I recommend a larger machine to improve deflection because of the minimal ground-lead constraint and proximity to the stream below. These same settings would be used to log the adjacent units to the north (See Ecological Thinning Unit E 4, 5, & 6 below).

Ecological Thinning Unit E 2

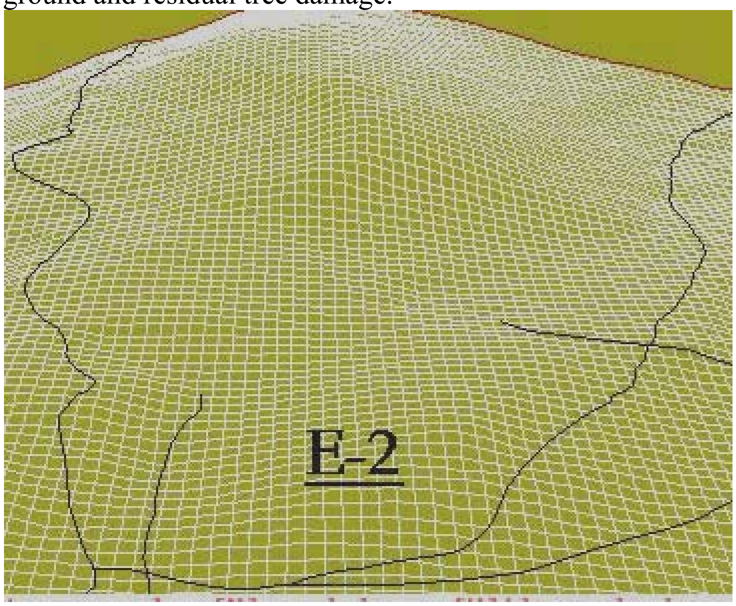
Ground Based

The terrain meets the criteria for the entire unit. A system of parallel corridors placed such that logs can be forwarded west to the main line. There are two streams that are identified. Forwarding raods will have to be designed to avoid the riparian reserves but should not affect production

Skyline Not necessary

Helicopter

A small ship will yard these payloads easily to the main line. While expensive (~$250-300/Mbf) there will be minimal ground and residual tree damage.



Recommendations

Ground Based

The terrain meets the criteria for the entire unit. A system of parallel corridors placed such that logs can be forwarded west to the 700 main line. There are two streams that are identified. Forwarding roads will be designed to avoid the riparian reserves so as not to affect production.

Logs from a skyline setting for ETU-3 could be forwarded, saving the cost of building a log loading landing.

Ecological Thinning Unit E 3

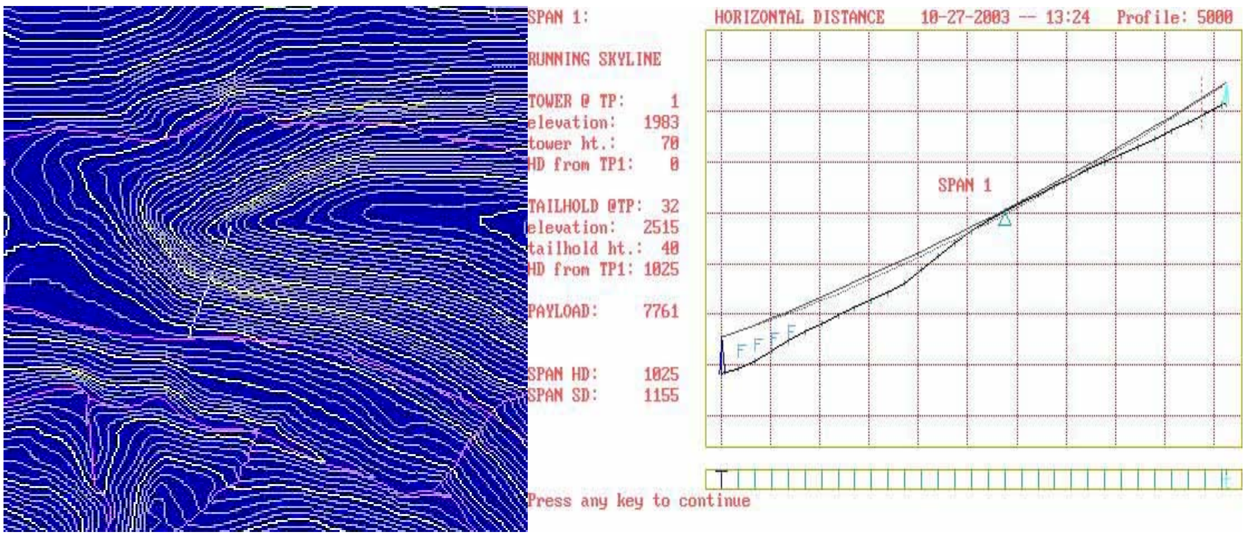
Ground Based

The terrain is unacceptable for entire unit. A small patch on the west end may be accessed with the ground based system described in Ecological Thinning Unit E 2

Skyline

A small tower (~70 foot tall Thunderbird TMY-70) will be able to yard both North and South to the main line. However, full-suspension with a 40 foot tailblock is limited the lower half of the slope as depicted below. Full suspension will require the use of intermediate supports—both time consuming and expensive. The face to the west is problematic with out building a road to the bottom of the hill out on the flat in Ecological Thinning Unit E 2.

Building a road west all the way out to the top of the ridge will be expensive will allow a central landing to cover the entire west end of Ecological Thinning Unit E 3. This will still require intermediate supports to yard uphill. This is feasible only if a road is built and the road will not likely be built large enough to mobilize a TMY-70 type tower. A smaller machine will still pull the payloads uphill but with more settings and less lateral yarding capability.



Helicopter

A small ship will yard these payloads west to the main line. While expensive, there will be minimal ground and residual tree damage.

Combination Setting

A combination of a small tower (~70 foot tall) that will downhill yard the North and South faces and helicopter for the remainder may also be feasible. This option would yard downhill the lower slopes, what timber is left will be heli-logged and taken west to an expanded landing. The expanded landing would be designed for repeated use in developing future Ecological Thinning Units.

This option avoids expensive road building along the ridge. Non-merchantable material will be slashed and left on site as per the contract (e.g. “slashed so all material lays on the ground”).

Recommendations

Combination Setting

A combination of a small tower (~70 foot tall) that will downhill yard the North and South faces and helicopter for the remainder may also be feasible. There appears to be sufficiently large trees and stumps to anchor tower guylines along the road. This option yards the lower slopes downhill, with intermediate supports to extend yarding as far as possible. Remaining timber will be heli-logged and taken west to an expanded landing. A small ship will yard these payloads west to the 300 or4 700 main line. The addition of intermediate supports extends the range of yarding while reducing the amount of helicopter yarding. This may be a cost saving measure in general.

As an option, a small temporary access to the western base of the ridge would allow a small skyline yarding downhill into ETU-2. This set up will reduce the amount of helicopter yarding required in ETU-3.

Ecological Thinning Unit E 4

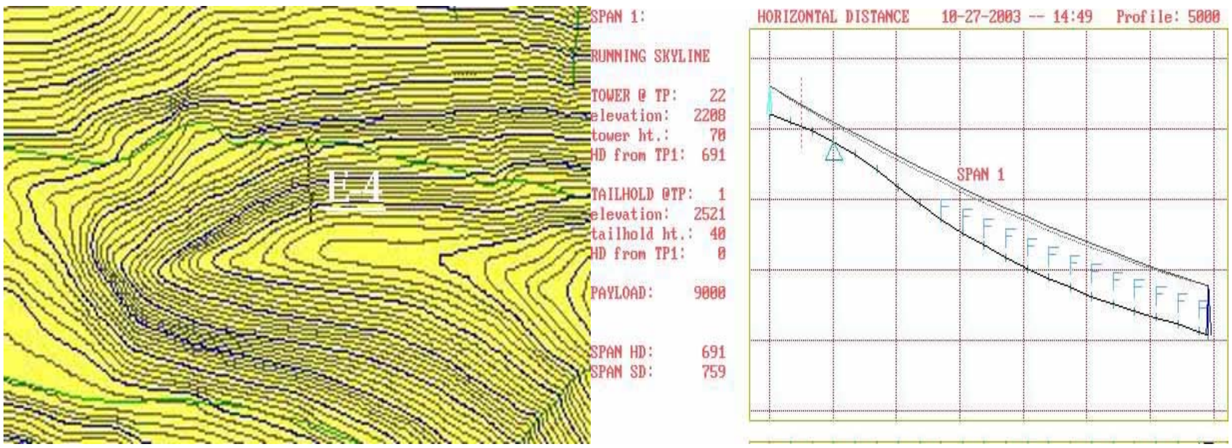
Ground Based

The terrain is unacceptable for entire unit.

Skyline

A small tower (~70 foot tall Thunderbird TMY-70) will be able to yard downhill to the North, landing logs on the main line. Full-suspension with a 40 foot tailblock is limited the lower half of the slope as depicted below. Full suspension for the full span to the ridge top requires intermediate supports.

Building a road west along the top of the ridge, while expensive, allows a series of parallel settings to cover the entire north face of Ecological Thinning Unit E 4. These settings require intermediate supports to yard uphill and is feasible only if a road is built. A smaller machine than the tall tower used for downhill (e.g. TMY 70) will still pull the payloads uphill but with more settings and less lateral yarding capability.



Helicopter

A small ship will yard these payloads easily to the main line. While expensive there will be minimal ground and residual tree damage.

Combination Setting

A combination of a small tower (~70 foot tall) that will downhill yard the timber from the lower portions of the North face. A helicopter can be used for the remainder. This option would yard downhill the lower slopes, what timber is left will be heli-logged and taken west to an expanded landing. The expanded landing would be designed for repeated use in developing future Ecological Thinning Units.

This option avoids expensive road building along the ridge. Non-merchantable material will be slashed and left on site as per the contract (e.g. "slashed so all material lays on the ground").

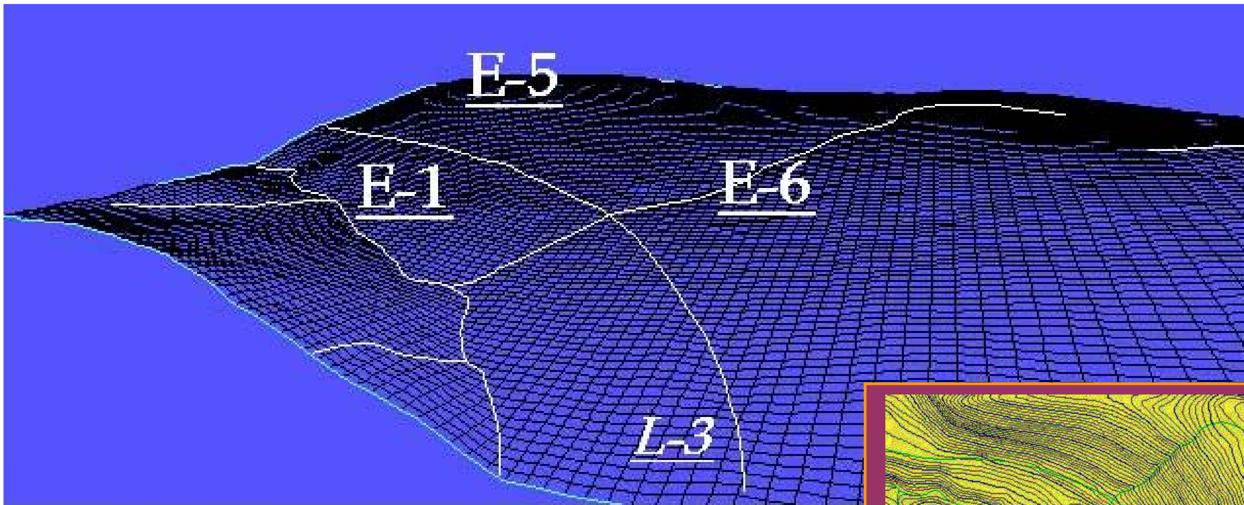
Recommendations

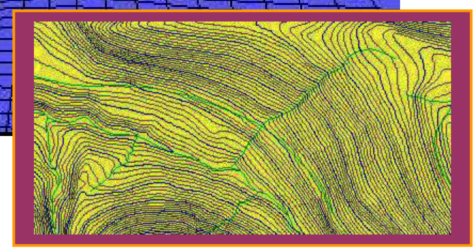
Combination Setting

A combination of a small tower (~70 foot tall) that will downhill yard the North and South faces and helicopter for the remainder may also be feasible. There appears to be sufficiently large trees and stumps to anchor tower guylines along the road. This option yards the lower slopes downhill, with intermediate supports to extend yarding as far as possible. Remaining timber will be heli-logged and taken west to an expanded landing. A small ship will yard these payloads west to the 300 or4 700 main line. The addition of intermediate supports extends the range of yarding while reducing the amount of helicopter yarding. This may be a cost saving measure in general.

As an option, a small temporary access to the western base of the ridge would allow a small skyline yarding downhill into ETU-2. This set up will reduce the amount of helicopter yarding required in ETU-3.

Ecological Thinning Units E 5 & 6





Ground Based

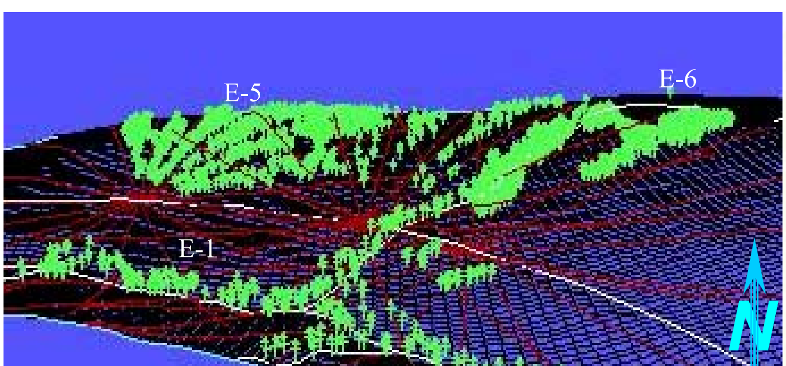
The terrain is unacceptable for most of the unit.
There may be areas, on the southern limit of the E T U – 5 / 6, and where some careful layout could yield several more settings in the basin.

Skyline

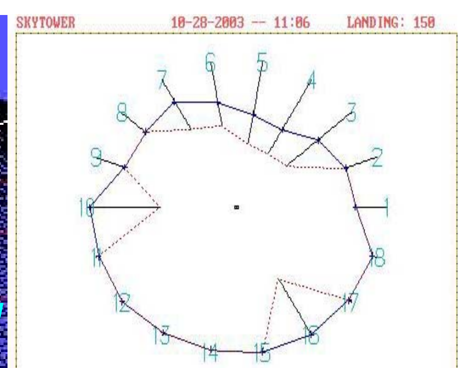
Numerous challenges offered by this setting, constrain the setting design. There is no crossing of the stream, as provided by the constraints above. The cutting prescription need not be modified. However, there is latitude in STR selection so as to gain optimal yarding efficiency with in the constraints.

As example, displayed here is a small tower (~70 foot tall) that will downhill yard the timber from the lower portions of the North face. This requires tall tail trees (e.g. ~100 ft for a 40 ft tailhold or better) and will most likely be from the pool of some of the largest trees on the site.

One of the best settings, which takes advantage of the natural bowl shape of the little catchment in the middle of Ecological Thinning Unit E-6, is displayed to show the possible configuration of a riparian adjacent landing. This is a central landing and represents how close a tower might sit relative to the adjacent RMZ.

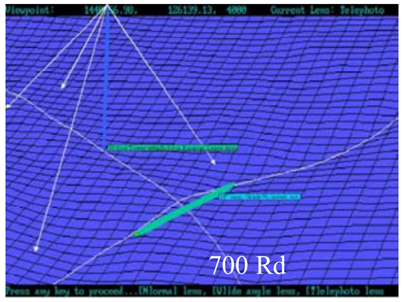


ETU- 5 & 6 with an example of STR arranged for operational efficiencv.



Setting Boundary for ETU-6 with modified corridor configurations.

At the most extreme, lacking all other guy line opportunities, residual reserve trees can be used to safely anchor skyline towers. Selection would be for trees that would provide good quality habitat as snags.



Helicopter

A small ship will yard these payloads easily to the main line. While expensive, there will be minimal ground and residual tree damage. This option avoids expensive road building along the ridge but requires the development of modified landings for the ship and log deck.

Combination Setting

A combination of a small tower (~70 foot tall) that will downhill yard the timber from the lower portions of the North face. A helicopter can be used for the remainder. This option would yard downhill the lower slopes, what timber is left will be heli-logged and taken west to an expanded landing. The expanded landing would be designed for repeated use in developing future Ecological Thinning Units.

This option avoids expensive road building along the ridge. Non-merchantable material will be slashed and left on site as per the contract (e.g. “slashed so all material lays on the ground”).

Recommendations

These settings offered numerous challenges that constrain the design. There is no stream crossings, as provided by the constraints above. The cutting prescription need not be modified. However, if given some latitude in STR selection, there may gains in yarding efficiency that would optimize cost and ecological goals—within the given constraints.

Ground Based

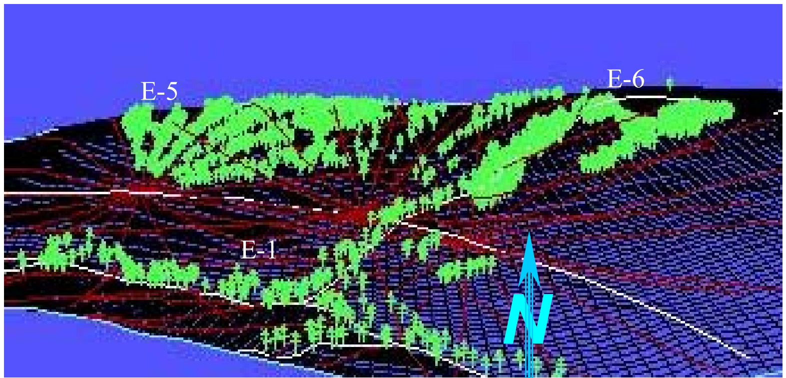
There may be areas, on the southern and eastern limit of the E T U – 5 / 6 where some careful layout could yield several more settings in the basin.

Combination Setting

A combination of a small tower (~70 foot tall) that will downhill yard the timber from the lower portions of the North face and a helicopter for the remainder. This option would yard the lower slopes downhill, what timber is left will be heli-logged and taken west or east log landings at either the 300-700 rd intersection of to the 300-310 rd intersection. A small ship will yard these payloads easily to the main line.

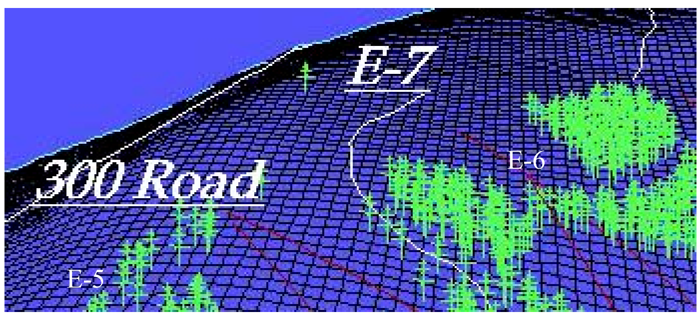
As example (cited in the comprehensive report), a small tower (~70 foot tall) would reach farther for the downhill yarding of the lower portions of the North face. Tall tail trees will be retained as STR on the site. Residual reserve trees can be used to safely anchor skyline towers. Selection would be for safe trees that would provide good quality habitat as snags.

One of the best settings, which takes advantage of the natural bowl shape of the little catchment in the middle of Ecological Thinning Unit E-6, is displayed to show the possible configuration of a riparian adjacent landing. This is a central landing and represents how close a tower might sit relative to the adjacent RMZ. Additional, Parallel settings along the 700 mainline can be used to minimize the residual stand damage and are necessary to log below the 700 road in ETU-1.



ETU- 5 & 6 with an example of STR arranged for operational efficiencv.

Ecological Thinning Unit E 7



Ground Based

The terrain meets the criteria for the entire unit. A system of parallel corridors placed such that logs can be forwarded east to the new road construction (311?) and then west to the main line

Skyline

Not necessary

Helicopter

A small ship will yard these payloads easily to the main line. While expensive there will be minimal ground and residual tree damage. This option avoids expensive road building along the ridge. Non-merchantable material will be slashed and left on site as per the contract (e.g. “slashed so all material lays on the ground”).

Recommendations

Ground Based

The terrain meets the criteria for the entire unit. A system of parallel corridors placed such that logs can be forwarded east along existing grades (311?) to the 300 Main line then west.

Restoration Thinning Unit 1

As the material is all non-merchantable,

Ground Based

Not feasible

Skyline

Not necessary.

Helicopter

Not necessary.

This unit should be slashed on site (e.g. PCT). A specification in the contract should state that the material will lay on the ground (e.g. cut to ~approx 4 feet in length). Spacing should be about 18 feet, leaving trees only 10 inches and better. This selection rule will randomize residual pattern and rid the stand of suppression stems. By the inventory, that would be about 130 tpa, half fir, and the other quarters are redcedar and hemlock. Selection can favor isolated Noble fir, yellow cedar, mountain hemlock, and hardwoods.

Recommendations

As the material is all non-merchantable, this unit should be slashed on site (e.g. PCT). A specification in the contract should state that the material will lay on the ground (e.g. cut to ~approx 4 feet in length). Cost will be greater to lay material on the ground but it will reduce fuels risk and more rapidly be incorporated into useable site nutrition.

Spacing should be about 18 feet, leaving trees only 10 inches and better. This selection rule will randomize residual pattern and rid the stand of suppression stems. By the inventory, that would be about 130 tpa, half fir, and the other quarters are redcedar and hemlock. Selection can favor isolated Noble fir, yellow cedar, mountain hemlock, and hardwoods.

DISCUSSION

While more detailed analysis is possible, these are the essential concepts one will use to convey CRW intent with the harvest methods.

Timber cruises already are quite sophisticated. The key is to develop methods to extract and compute parameters, such as log sizes and weights for payload analysis.

Harvest planning can be more efficient if done along side the silvicultural and ecological design. As an after thought, the unit boundaries may seem awkward and misplaced. The design process should work together and often requires iteration. Once boundaries become static, the harvest planning process can become cumbersome while trying to fit designs to arbitrary landscape delineation.

There are numerous ways to solve problems that arise as a result of unit by unit harvest plans. The efficiency is gained by looking more broadly and with more detailed information on terrain and timber. Digital terrain models being developed now using LIDAR technology have proven effective beyond expectations, identifying detailed landforms that may indicate instability, previous road cuts, and more sophisticated hydrologic patterns.

CONCLUSIONS

The 700 road ETU is a difficult piece of ground; steep ground, limited access, and small timber offer challenges in the overall design. Harvest costs alone are not the driver but every effort should be made to minimize costs when timber receipts are expected to be low.

These recommendations are one set of solutions that certainly have room for design improvements and modifications as more information accumulates.

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